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LABORATORY STUDY OF TWO GRASSES GROWN ON COPPER TAILINGS SUPPLEMENTED WITH ALUMINUM ALUM

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INTRODUCTION

In a portion of the Upper Peninsula of Michigan (Houghton and Keweenaw Counties) large deposits of tailings from copper mines have been dumped on land and in lakes, making large barren deposits. Many of these deposits pose no problem other than unsightliness; however, some of the tailings were reclaimed and in the process were ground to the consistency of a find sand. These fine particles were dumped back into the areas from which they were removed, and now provide a nuisance factor in that breezes are able to pick up the dried tailings and carry them to nearby communities. A program of revegetation was begun to control the blowing tailings particles and change the unsightliness. Although revegetation of other mine tailings has been successfully carried out in various areas (Dean, Havens, & Harper, 1969; Dean & Havens, 1970; James, 1966; Nielson & Peterson, 1972; Shetron & Duffek, 1970) the revegetation of the Upper Peninsula copper mine and reclaimed tailings has, thus far, proved somewhat unsuccessful.

Those persons working on tailings revegetation used various methods to prevent water evaporation from the tailings (Shetron & Ritter, 1973) and to provide nutrients for plants. These methods including adding mineral fertilizers, manure, decaying woodchips, and wood fiber mulch. In all these attempts seedlings would begin to grow but would die before establishing themselves.

My initial greenhouse and laboratory experiments with tailings were unsuccessful in producing healthy plants. Plants were grown in tailings, in mixtures of tailings and Perlite, tailings and decaying sawdust, tailings and manure. They were fertilized with complete nutrient solutions and watered several times a week. The factors which appeared to be limiting in the field (water and available nutrients) were not limiting in the greenhouse, yet the plants did not grow properly. Grasses grown on tailings were chlorotic with leaves so weak they were not able to support themselves. Tomato plants were also chlorotic, the stems were somewhat contorted with long internodes, and the leaves were from ½ to ¼ the size of normal leaves (Erbisch, unpublished data).

It would appear that a growth inhibitor(s) is present in the tailings. In fact, it may pose more of a problem for plants growing on tailings than the availability of water and nutrients.

Although no growth inhibitor has been isolated from the tailings, one could assume that the inhibitor would be copper. Analyses of the sands by various individuals have shown that the copper content of the tailings ranges from 200 to 2000 ppm (pers. comm., Larry L. Babcock, Research Engineer, Institute of Minerals Research, Michigan Technological University). The copper availability to the plants could be in excess of what is needed by the plant and could poison or inhibit its growth (Stiles, 1961).

Liebig, Vanselon, and Chapman (1942) showed that citrus cuttings would not root in solutions containing excess copper unless a small amount of aluminum was added. The aluminum apparently counteracted the effects of the excess copper. Believing that aluminum might counteract the effect of the copper tailings inhibitor, I carried out a series of experiments.

MATERIALS AND METHODS

Tailings. The tailings were collected from an area called the Tamarack Sands near Hubbell, Michigan. The top six to seven inches of tailings were placed in plastic bags and taken to the laboratory for further growth studies. The tailings collected were those on which earlier revegetation attempts had failed.

Mineral Nutrient Solution. Since the tailings were lacking in almost every mineral element, it was necessary to make a complete mineral nutrient solution. The nutrient solution, Hoagland's solution, was made according to instructions given by Machlis and Torrey (1956). Plants were grown either in the mineral nutrient solution or in tailings and watered every three days with 100 ml of solution.

Mineral Nutrient Solution With Aluminum Alum. The mineral nutrient solution was as above with the addition of 0.6 gram of $Al_2\ (SO_4)_3\ (NH_4)_2\ SO_4 \cdot 24H_2O$ (aluminum alum) per liter. Plants were grown in the mineral nutrient solution with aluminum or grown in tailings and watered every three days with 100 ml of solution.

Plants. The plants used in the series of experiments were two grasses, redtop (*Agrostis alba*) and fescue (*Festuca* sp.). These grasses, which were purchased locally, had been used at the tailings site for revegetation purposes. They were used in my study to provide continuity from field to laboratory.

Growing Conditions. For those plants growing in tailings or soil, 1-quart plastic cottage cheese cartons were used. Small holes were punched in the bottom of the cartons, which were then filled with either soil or tailings and approximately 50 seeds placed on top.

For those plants grown in the mineral nutrient solutions, 1-quart jars were used. The jars were filled with the proper nutrient solution, fiberglas screens were placed into the top of the jars, and approximately 30 seeds were placed on the screen. The screen was positioned so that the seeds would just be moistened by the nutrient solution. The jars were covered with aluminum foil to prevent algal growth.

In some cases tailings were added to the mineral nutrient solutions: 100 grams, 250 grams, and 500 grams. The tailings were placed in the bottom of the jar and the nutrient solution was added.

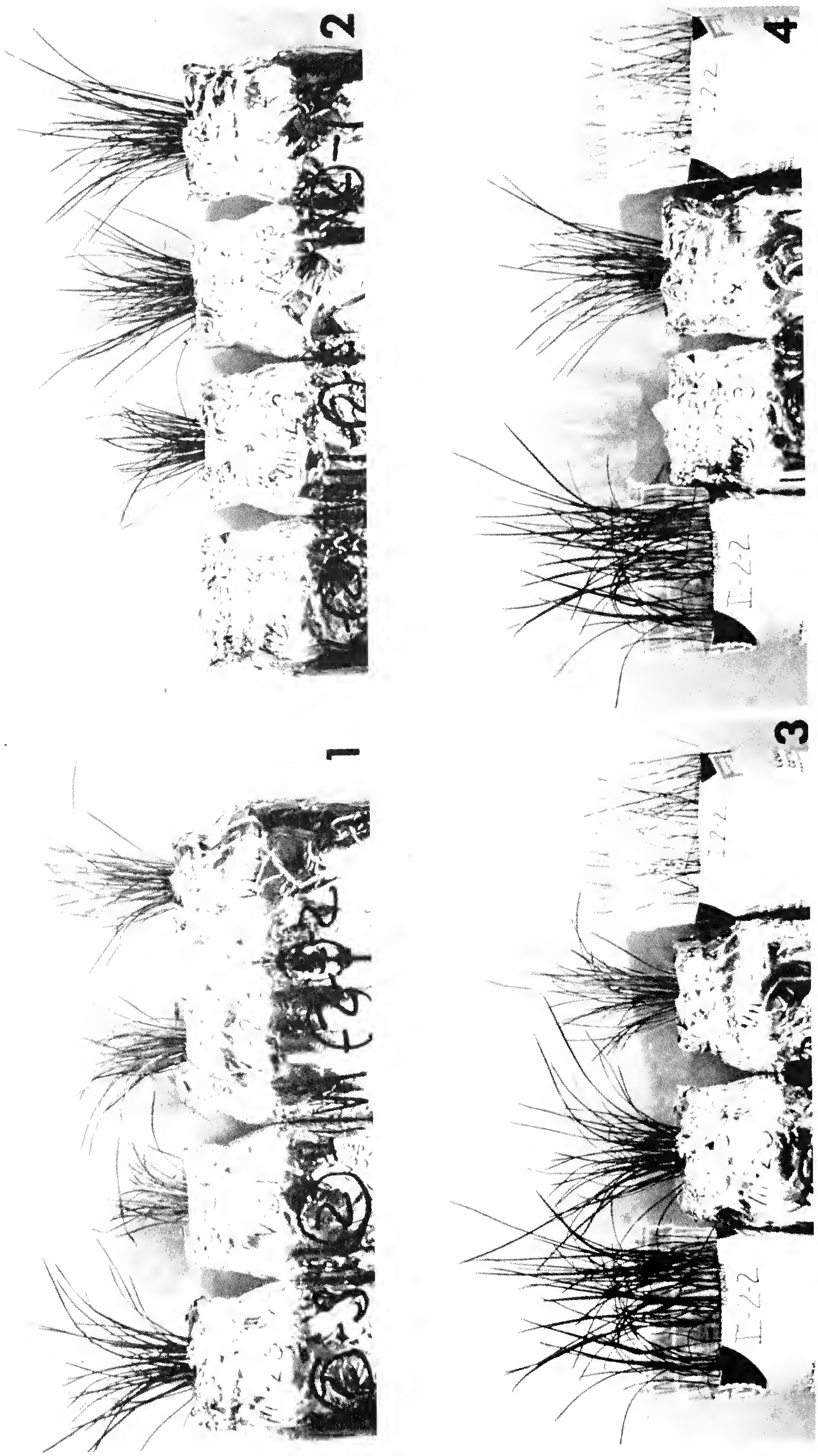
During the 3½-week growth period all cartons and jars were placed in a greenhouse. The plants in cartons were watered with distilled water whenever

TABLE 1. Growth of redtop grass in various media. (MNS = mineral nutrient solution. Al = 0.6 gm Al $(SO_4)_3(NH_4)_2SO_4 \cdot 24H_2O$/liter of mineral nutrient solution.)

Medium	Initial pH	Final pH	Average Length of Leaves (cm)	Color of Leaves	Average Length of Root (cm)	Color and Branching of Root
MNS	4.3	6.1	12	dark green	10.5	tan, many branches, sturdy
MNS + 100 gm tailings	5.7	6.6	12	yellow and green	15	white, few branches, thin and fragile
MNS + 250 gm tailings	5.9	6.8	13	yellow and green	13	white, few branches, thin and fragile
MNS + 500 gm tailings	6.0	6.8	12	yellow and green	13	white, many branches, thin and fragile
MNS + Al	3.2	3.2	0	dead	0	dead
MNS + Al + 100 gm tailings	3.6	6.2	10	dark green	11	tan, few branches, sturdy
MNS + Al + 250 gm tailings	4.2	6.2	15	dark green	13	tan, few branches, sturdy
MNS + Al + 500 gm tailings	5.0	6.5	17	dark green	7	tan, many branches, sturdy
Soil–100% (No MNS)	5.4-5.6	–	12	dark green	15	tan to dark, many branches, sturdy
Tailings–100% (No MNS)	8.2-8.4	–	8	yellow	7	White, few branches, thin and fragile

TABLE 2. Growth of fescue grass in various media. (MNS = mineral nutrient solution. Al = 0.6 gm $(SO_4)_3(NH_4)SO_4 \cdot 24H_2O$/liter of mineral nutrient solution.)

Medium	Initial pH	Final pH	Average Length of Leaves (cm)	Color of Leaves	Average Length of Root (cm)	Color and Branching of Root
MNS	4.3	6.7	11.0	dark green	11	ten, many branches, sturdy
MNS + 100 gm tailings	5.7	6.7	8.0	yellow and green	11	white, few branches, thin and fragile
MNS + 250 gm tailings	5.9	6.9	9.7	yellow and green	15	white, few branches, thin and fragile
MNS + 500 gm tailings	6.0	7.1	9.3	yellow and green	14	white, some branches, thin and fragile
MNS + Al	3.2	3.2	0	dead	0	dead
MNS + Al + 100 gm tailings	3.6	6.4	9.2	dark green	8.5	tan, few branches, sturdy
MNS + Al + 250 gm tailings	4.2	6.6	10.7	dark green	13	tan, many branches, sturdy
MNS + Al + 500 gm tailings	5.0	6.9	11.7	dark green	13	tan to dark, some branches, sturdy
Soil–100% (No MNS)	5.4-5.6	–	13.3	dark green	15.6	tan to dark, many branches, sturdy
Tailings–100% (No MNS)	8.2-8.4	–	7.3	yellow	10	white, few branches, thin and fragile



dry and with nutrient solution every three days (100 ml). Periodically, distilled water was added to the mineral nutrient solution jars to keep the solutions at the proper level.

At the conclusion of the experiment, I compared the leaves and roots of the grasses and the pH of the various nutrient solutions.

RESULTS

Plants grew best in the soil and in the mineral nutrient solution. Plants grown in or with tailings and receiving the mineral nutrient solution with the aluminum supplement, compared favorably with soil-grown plants, having the same coloration as well as sturdy leaves and roots. Plants grown in or with tailings and not receiving the aluminum-supplemented mineral nutrient solution appeared chlorotic, with thin, weak leaves and roots. Seeds grown in only the aluminum-supplemented nutrient solution died soon after germination. The results of the experiments are summarized in Tables 1 and 2 and Figures 1-8.

DISCUSSION

Establishment of seedlings on tailings or in solutions containing tailings is enhanced by the addition of aluminum to the nutrient solution. This aluminum mineral nutrient solution by itself was toxic to plants, but when mixed with tailings appeared beneficial.

The experiments also tend to show the presence of an inhibitor in the tailings; those plants in bottles containing the mineral nutrient solution with aluminum and only 100 grams of tailings grew less than did those in bottles containing 500 grams of tailings with the aluminum containing mineral nutrient solution. Perhaps the toxic element of the aluminum supplement is being tied up by the inhibitor in the tailings, making both inactive. If not enough tailings inhibitor is present the toxic element of the aluminum supplement tends to retard the growth of plants. When the proper amount of aluminum to deactivate the inhibitor is in contact with the tailings, growth of the seedling approaches that of one grown in soil.

The use of aluminum along with fertilizers for the establishment of seedlings on the tailings is being carried out during the summer of 1973. Many

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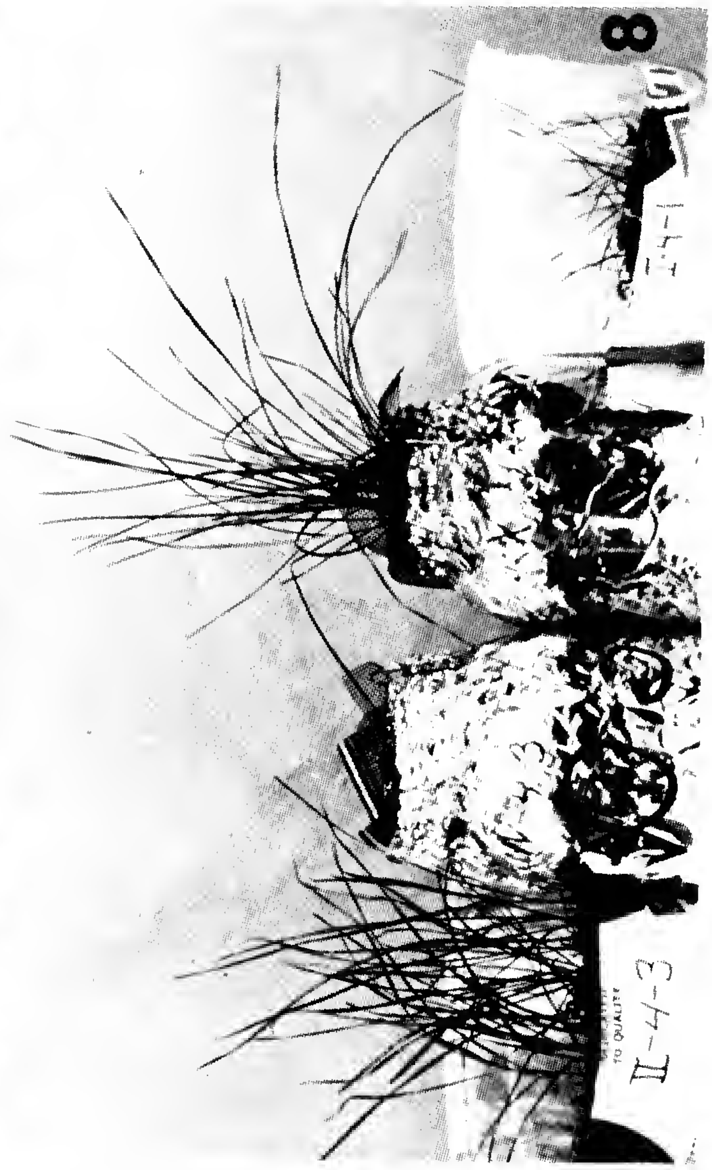
Figures 1-4. Growth of redtop grass in different media, after 3½ weeks.

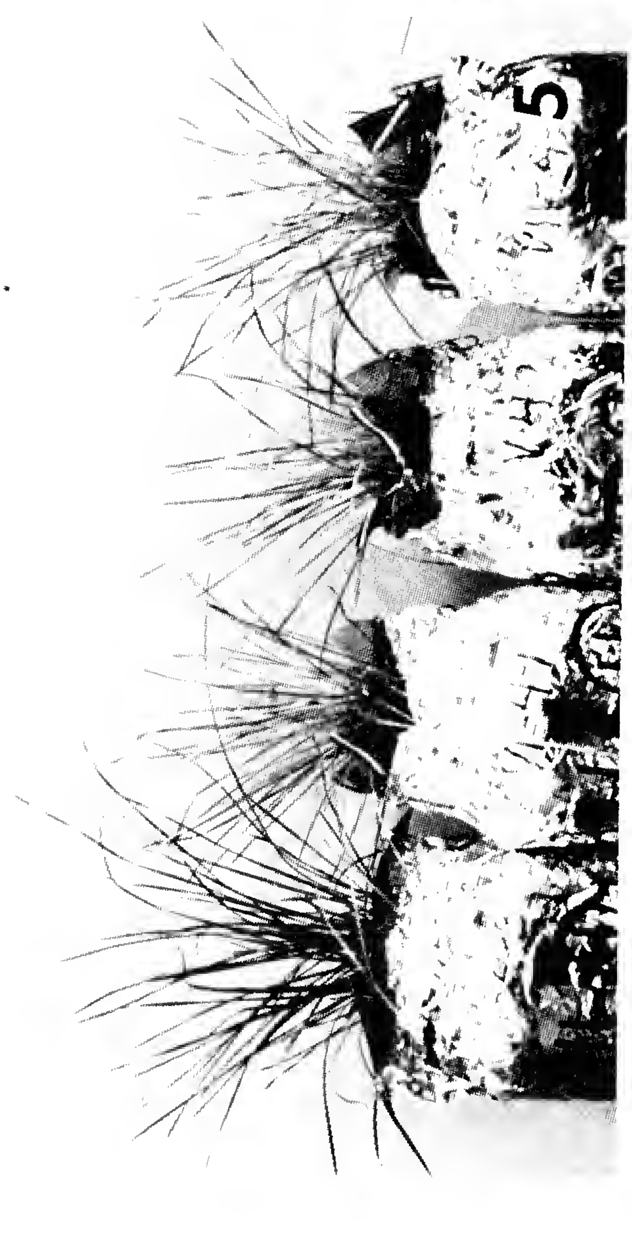
Fig. 1. From the left, mineral nutrient solution, mineral nutrient solution + 100 grams of tailings, mineral nutrient solution + 250 grams of tailings, mineral nutrient solution + 500 grams of tailings.

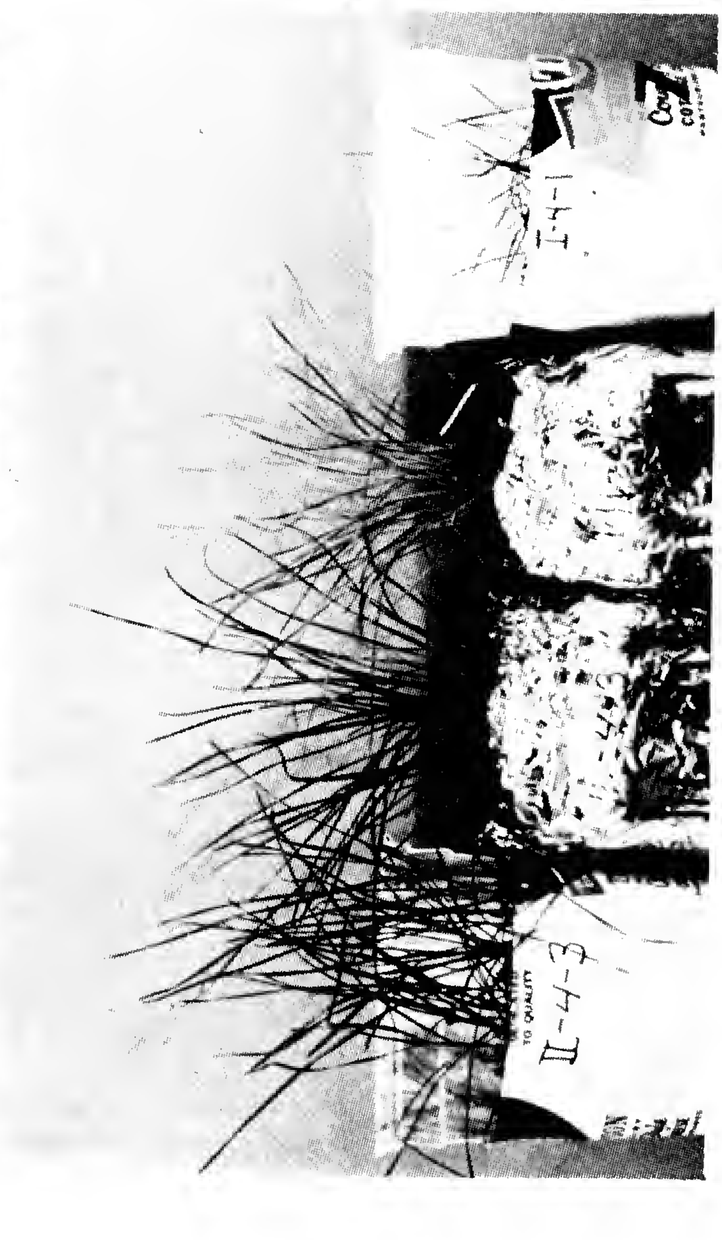
Fig. 2. The solutions are identical to those of Fig. 1 with the addition of 0.6 grams/liter of aluminum ammonium sulfate in each container.

Fig. 3. From the left, soil, mineral nutrient solution, mineral nutrient solution + 500 grams of tailings, tailings.

Fig. 4. From the left, soil, mineral nutrient solution with aluminum ammonium sulfate, mineral nutrient solution with aluminum ammonium sulfate + 500 grams of tailings, tailings.







1M square plots were set up on the tailings to determine the beneficial effects of aluminum in the field.

SUMMARY

Various attempts by several different investigators to revegetate copper tailings in Houghton County, Michigan, have been unsuccessful. Water and available nutrients appeared to be the limiting factors for growth; however, laboratory and greenhouse experiments have shown that an inhibitor in the tailings also prevents growth. In this study it was shown that the addition of small amounts of aluminum tended to counteract the effects of the inhibitor. Plants grown in the greenhouse on tailings fertilized with an aluminum-containing nutrient solution compared favorably with those grown on soil.

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Figures 5-8. Growth of fescue grass in different media, after 3½ weeks.

Fig. 5. From the left, mineral nutrient solution, mineral nutrient solution + 100 grams tailings, mineral nutrient solution + 250 grams of tailings, mineral nutrient solution + 500 grams of tailings.

Fig. 6. The solutions are identical to those of Fig. 5 with the addition of 0.6 grams/liter of aluminum ammonium sulfate in each container.

Fig. 7. From the left, soil, mineral nutrient solution, mineral nutrient solution + 500 grams of tailings, tailings.

Fig. 8. From the left, soil, mineral nutrient solution with aluminum ammonium sulfate, mineral nutrient solution with aluminum ammonium sulfate + 500 grams of tailings, tailings.

Miss Ruth Hoppin, 1882. (Photograph from the Smith College Archives, Northampton, Massachusetts.)

MISS RUTH HOPPIN, PRECEPTRESS AND BOTANIST 1833-1903

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Among the specimens in the herbarium of Eastern Michigan University at Ypsilanti, Michigan, are over 400 collected by Miss Ruth Hoppin during the period 1856 to 1880. The rather surprisingly good condition of many of the specimens, plus the variety of collection localities represented, stimulated my interest in the person herself, as I cataloged the collections. When I set out to learn more of her life story, the trail led first to the University archives, then to the Three Rivers (Michigan) Public Library, then on to Oberlin College, Ann Arbor (Michigan) High School, the Agassiz Museum at Harvard, Smith College in Massachusetts, and may not yet be complete, as new information opens up new areas of search.

. The story which emerges is of a remarkable, dedicated, and energetic woman whose teaching career spanned fifty years, and whose life took her from the crudities and dangers of frontier life in Michigan to a college degree in an era when few women achieved such a distinction. With rare vigor and determination she moved in an ascending series of positions as teacher and preceptress, to additional study and travel in far places, including Europe, and finally back to her beloved home in Three Rivers, to wait out the years of declining health until her death. Her local biographers spoke of her with respect and affection.

The bare outline of her life was not too difficult to determine. But what was she like, she herself? We can only surmise. Brief impressions, like flashes of light reflected up through the years from the faces of letters, from old books, from her own words, fill in the outlines. A photograph of her, from the Smith College archives, shows a woman of middle age, with gentle eyes and a firm mouth. If physiognomy is to be believed, this expresses her character.

She was born in what is now Hanover Township, Chautauqua County, New York, on December 17, 1833, to Samuel and Rebecca Hoppin.[1]

The child Ruth Hoppin was born into a family of ideals and traditions. The Hoppin line was descended from Revolutionary ancestors, Ruth's paternal grandfather Samuel having served as a private in a detachment of the Hampshire militia at Ticonderoga, and his wife's father, Thaddeus Curtis, under Col. Marenus Willet "on Mohawk river" and in Col. David Moseley's (Hampshire Co.) regiment.[2]

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[1]Semi-centennial register, 1833-1883, Oberlin College.

[2]Most of the details of Miss Hoppin's early life were obtained from her own "Personal recollections of pioneer days" (1926). Exceptions are noted.

Her father, Samuel, was a "Massachusetts man from the Berkshire region. . . . He was one of the early pioneers upon that section of western New York which was known at the time as 'The Holland Purchase.' He served, for a time, in the war of 1812-14" (Putman, 1899).

Her mother "was of Scotch and English descent. She had played, as a child, at the feet of Bishop Asbury, the first of the Bishops of the Methodist Episcopal church in America. The Bishop was a frequent visitor at her father's house in Byram, New York." Miss Hoppin later was to say, "Some of the very best things which came into my early religious life, came from this source" (Putnam, 1899).

In the spring of 1836, when Ruth was three years old, the family, including at least four children and her uncle Curtis Hoppin, emigrated to Michigan, bringing in their wagons a few cherished belongings—her mother's arm chair, a Windsor chair—over the crude trails.

Their first sojourn was in the Edwin H. Lothrop neighborhood at Prairie Ronde, given by one historian (Silliman, 1926) as being in Kalamazoo County, but by Miss Hoppin herself, in a later paper, as being "in the northern part of the [St. Joseph] county."[3] There a sort of village had been started, near the Buckhorn tavern, with nearly a half dozen houses lying within a half mile of one another.

Years later, in a paper read before the meeting of the St. Joseph County Pioneer Association, at Centerville, Miss Hoppin recounted memories of those early days.

The sign of the Buckhorn tavern, a deer's horn fastened to an upright tamarack pole, named the inn, the neighborhood, and the road winding through the forest from Prairie Ronde to Three Rivers. Representative of pioneer stopping places, it was a two-story clapboarded frame building, destitute of paint or plaster. Bed quilts and blankets served as partitions where rough boards and studding failed to be adequate. The bar-room/sitting room, reached by the one outside door, was sparsely furnished with splint-bottomed chairs, and held the bar with its sparkling bottles and glasses. It was heated by a great brick fireplace, the services of which were needed even in autumn, the building being but a shell. A second front room contained beds. If these were filled, the emigrant might take from his covered wagon his own beds and spread them on the floor. A third room, running back, also with a huge fireplace, served as combination kitchen and dining room.

Another building of the neighborhood was the distillery, remembered by Miss Hoppin with distaste for the smells and squeals of the adjacent pigpens, for the unsavory hangers-on, and for the drunken Indians who came there from the reservation in Park for "fire water."

These Indians stopped at neighboring houses demanding food and whiskey, and sometimes wanting to fight. Refusing her mother's pies, they always asked for bread, flour, and pork, which they cut in half-inch-thick

[3]It is probable that the Prairie Ronde of Miss Hoppin referred to the physical, not the political, entity. The township of that name lies in Kalamazoo County; the prairie is less tightly defined.

slabs, laid between thick slices of bread, and ate raw. In return, they brought gifts of berries, maple sugar, fish, venison, or young turkeys, often carried in mocoes, round band boxes of bark sewed together with a thread of bark or twigs. In spite of the friendlier side of their actions, the terror of these Indians hung over Ruth Hoppin's childhood, after a neighbor was murdered at his own fireside, so that at times she seemed to see an Indian behind every stump on the way to school, and nightmares haunted her until she was grown up. She was thankful when they were deported to the Indian territory, although her parents deplored the act.

Later, moving to Park, the family settled in the woods, and knew "in winter the wolf's howl, in the spring the thrum of the prairie hen, and in summer the song of the whip-poor-will." Herds of deer and flocks of wild turkeys frequented the woods, and the neighbors were visited by bears. The unlimited pasture of the cattle was offset by the cow's habit of wandering off for a week at a time.

The land surrounding the house, when cleared, yielded abundant harvests of corn, pumpkins, and melons. In addition, strawberries, huckleberries, and cranberries were gathered from field and swamp. Frontier wives cooked by open fireplaces, baking in tin ovens or the old-fashioned bake-kettle, producing bread and pies and toothsome pumpkin Johnny cake.

Ruth's mother spun, wove, colored, and made up clothing for her large family, until the invention of machinery and the new railroad brought calico at twelve and a half cents and delaine at twenty-five cents a yard, and the spinning wheel and loom were put aside.

The plank walls of her home, unplastered, were papered with newspaper. An attempt to color doors and partitions with red lead mixed with lard never dried, so that color rubbed off on their clothing.

Floors were scrubbed with home-made splint brooms, until water dashed on and swept off "ran clear enough to drink."

Most of the furniture had been brought on the emigrant's wagons—the common splint-bottomed chair, the elegant Windsor chair or "winzy," and perhaps a particular treasure. Bedsteads might have turned posts, with ropes drawn through holes bored in the rudely squared bed rails as support for the bedding. The grandest piece of furniture known in the settlement was a mahogany bureau, which "many went to look at with great curiosity."

"People who had linen for the table made it themselves; not until late in the forties did the Irish peddler bring in a plentiful supply of tablecloths."

> Musical instruments were few, the fiddle the most common. Some had accordions but few could play them. When the first organ grinder came through, he was greeted with joy, and some wanted to know if that thing he carried on his back were not a piano. We had much singing of songs, mostly English ballads and Scotch airs. The songs of Burns were as familiar to us as to the Scotchman in his native land, but few songs of American authorship were popular. Such a one was 'Oh, doubly mournful is the fate that I am called to relate,' and 'James Bird, the White Pilgrim' was another. . . .
>
> The old-fashioned winter evening visits brought to your door at sunset a large wagon load of men, women and children. They remained till towards morning; a hearty meal was served about midnight. The time was filled with

> singing and stories. Ghost stories were most popular, but war stories had a part. There were still living not a few men who had seen Washington and Wayne, who, like my father, had fought in the war of 1812. We were told how Perry's heroes looked as they marched through western New York to reach the squadron being built on Lake Erie. We heard the story of men who fought at Tippecanoe or who escaped the massacre at Frenchtown. The war of 1812 was always spoken of as the 'late war.'

Illness and death were somber threads in the fabric of pioneer life. Malaria, which people of the time attributed to malarial gases set free from the earth by plowing, was a serious threat. Ruth Hoppin recalled that "the country became very sickly. My father shook with the ague every day for eighteen months; there were ten all down at once, my mother the only one able to administer the cup of cold water and care for the sick." Not only did "Mother Hoppin" care for her own family. This woman of remarkable personality, rich in human sympathy and helpfulness, "was sent for far and near to nurse the sick and minister to those in trouble" (Silliman, 1926).

Local schools of the period offered limited education. Ruth Hoppin's early schooling was obtained in the little country school at Park, where she in turn, a few years later, was to be the mistress. An account of this time is best expressed in her own words.

> Much of the time till fifteen years of age my only schooling was obtained by walking two miles and a quarter through the dust of Prairie Ronde in the summer and its drifting snows in the winter. The teaching in country schools, then, might not have been as scientific as now, but those schools had then an element that the district school today has lost, namely, the stimulus, moral and intellectual, of all the best minds in the district. I look back to this portion of my life with pleasure, as one of great value in fitting me for my life work. From early childhood I was always playing teach school, and at a very early age finally decided what my occupation should be.

Perhaps she was remembering those school days when she later wrote, "There was the old pedagogue who used to train ideas with rod and ruler, his school house a log cabin in the forest. Some fine specimens of men and women received their education in those same log cabins, though the learning was so very meagre" (Hoppin, 1874).

At the age of fifteen she accompanied relatives to New York and there for a year enjoyed better educational advantages. A relative later remembered her as being, at the time, a "bright eyed smiling girl of sixteen years, with a gay, merry laugh and a happy, courageous spirit."[4]

She was to need her courage. The next year, 1849, was one of crisis and decision in the Hoppin family. Her father, Samuel, died on March 23.[5] Was it this memory which caused her to recount sadly, years later, a description of pioneer funerals?

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[4]Reed, 1903. It should be noted here that Eliza Trump Reed was probably not her sister, who was mentioned later as Mrs. Reed. A Lizzie Trump was named in The Normal News of 1881 as reading a paper at the literary exercises of the alumni. Sue Silliman referred to "Eliza Trump Reed, one of her former pupils."

[5]St. Joseph County, Michigan: birth, death, marriage records, 1967.

> The funerals of forty years ago everybody attended. The neighbors were sympathetic and helpful; there was no expense for the plank coffin made by the nearest joiner and the white cambric shroud, which was the burial robe of men and women alike. Mourning was put on by women, even if it were nothing but a bit of black ribbon on a white straw bonnet. There were no flowers and no hearse, no undertaker. The body was carried in a common lumber wagon, the bearers riding in the same vehicle. The coffin was lowered into the grave by means of lines taken from the horses. All remained till the grave was filled up, the head and foot plank set in place, and the mound had been rounded and smoothed into its suggestive shape. Then it seemed that all had been done by kind friends, for each neighbor had taken a part in these duties.
>
> Now, we turn away from the open grave and leave this work to the hireling. The tunes and the hymns sung at funerals seemed purposely designed to make the bereaved ones sadder. There was little hope or consolation in either. Who of us elder ones do not remember "China" sung at all the pioneer funerals? The sermon, too, seemed to arouse, not to allay sorrow. He was the eloquent preacher who made the mourners cry the hardest.

The Hoppin family, now deprived of its father, was composed of a number of children, exactly how many this writer has been unable to determine. An older brother Thaddeus would have been twenty-five that year, but in one account Ruth Hoppin spoke of "elder brothers and sisters." Records of Thaddeus and of Ruth, John (born in 1836 in New York, a baby at the time of the emigration), and Eliza (born 1849) are found in the 1845 and 1850 census figures for St. Joseph County. Perhaps some had died of malaria, as suggested in the statement "ten down all at once." Two sisters, Mrs. Reed and Mrs. Kellogg of Park, were mentioned as sharing her later years (Reed, 1903). An uncle, Curtis, also lived with the family.

In the summer of 1849 the young Ruth taught in the Park school the children of twelve families, through the summer term, receiving besides her "experience" a total of six dollars and seventy-five cents (Silliman, 1931). It was her first school.

That fall, with her brother, she went to Oberlin. The brother was undoubtedly Thaddeus, and on this trip he seems to have been only accompanying his sister, for Oberlin records show his attendance there as being from 1851 to 1855. (He was to marry Catherine Annie Stuart in 1856. She had been born in Aberdeen, Scotland, in 1838, and had received her early education in Jamaica, W.I. Thaddeus and Catherine served as missionaries in Jamaica from 1856 to 1860, when they returned to Michigan and engaged in fruit farming, probably near South Haven. Six Jamaica specimens bearing Thaddeus' name, one dated 1856, are in the E.M.U. Herbarium.)

Of the momentous decision to enter Oberlin College, Ruth Hoppin later wrote, "In those days self education required both energy and will, and I fought the battle nearly alone. We had no good preparatory school near home; teachers' wages were much lower than now. It was a costly trip, by private conveyance and by railroad to Detroit, by steam boat to Cleveland, then thirty miles of staging to Oberlin."[6]

She entered the Young Ladies' Preparatory Department of the College,

[6]Letter from Ruth Hoppin to Daniel Putnam, 1898.

pursuing a curriculum given thus in the catalog of 1855-56: "Stoddard's Intellectual Arithmetic, Ray's and Stoddard's Practical Arithmetic, Modern Geography, Orthography, Reading, Andrews and Stoddard's Latin Grammar and Reader, Algebra to Equations of the second degree."

She then went on, with frequent absences, during which she was engaged in teaching, chiefly in the country schools of St. Joseph County, in order to earn enough to continue.

She was enrolled in the Ladies' Department 1851-53 and 1854-56. Presumably she followed the regular curriculum of the Young Ladies' Department, delineated in the same catalog:

FIRST YEAR

First Term.–Ray's Algebra, 2nd Part, commenced, Parsing, Reading and Oratory commenced, Linear Drawing.

Second Term.–Algebra completed, Parsing, Reading and Oratory Completed, Watts on the Mind.

Third Term.–Davies' Legendre's Geometry commenced, Burritt's Geography of the Heavens, Penmanship, Nevin's Biblical Antiquities.

SECOND YEAR

First Term.–Geometry continued, French, Lectures on Conchology, Weber's History.

Second Term.–Geometry completed, Plane and Spherical Trigonometry, Weber's History and Mitchell's Ancient Geography, Paley's Theology.

Third Term.–Conic Sections, Evidences of Christianity, Botany, Taylor's Manual of Modern History.

THIRD YEAR

First Term.–Olmsted's Natural Philosophy–Mechanics and Hydrostatics, Anatomy, Physiology and Hygiene, Principles of Zoology, Systematic Zoology.

Second Term.–Natural Philosophy–Pneumatics, Acoustics, Electricity, Magnetism and Optics, Chemistry commenced, Whately's Logic, Marsh's Ecclesiastical History.

Third Term.–Olmsted's Astronomy–Descriptive and Physical, Chemistry completed, Whately's Rhetoric, Mahan's Intellectual Philosophy commenced.

FOURTH YEAR

First Term.–Intellectual Philosophy completed, Mahan on the Will, Kames' Elements of Criticism, Dana's Manual of Mineralogy.

Second Term.–Hitchcock's Geology, Butler's Analogy, English Poetry, Lectures on Ancient Literature.

Third Term.–Mahan's Moral Philosophy, Guizot's History of Civilization, Political Economy, Constitution of the United States, Lectures on Modern Literature.

Lessons in English Bible, and Compositions, weekly, throughout the course.

She finally graduated in 1856, at the age of twenty-two, having taken seven years, because of the frequent absences, to complete her course, "with the diploma of the Literary Course (no degree)."[7] She wore, at her graduation, a "print dress of her own making" (Silliman, 1926).

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[7]This information was obtained from a report prepared by the Oberlin College Archives, April 13, 1950, in response to an inquiry from Mrs. Samuel D. Porter, 2770 Bedford Road, Ann Arbor, Michigan. Attempts on the part of the author to contact Mrs. Porter were unsuccessful. Any information about her would be appreciated.

Considering her lifelong interest in botany, evidenced early by plant collections dated 1856, a strong influence during her Oberlin years must have been that of James Dascomb, M.D., Professor of Chemistry, Botany and Physiology. New Hampshire-born, farm-raised, Dr. Dascomb had received his medical degree from Dartmouth College in 1833, the year Ruth was born. He had come to Oberlin, with his new bride, in 1834, and from the most meager beginnings, developed the teaching of chemistry, botany, and physiology. His biographer described him as thorough, methodical, conscientious and earnest, yet modest. The constant impression of his life, he said, was "Truth spreads out before us like a vast ocean, and we are only gathering pebbles upon the shore." He was a deeply religious man, self-disciplined, concerned with the public interest—church, school, and community. The planting of shade and ornamental trees in the town "came greatly from his thoughtfulness and taste."[8]

Another influence at Oberlin was Miss Sara Allen, who had been a high-ranking scholar as an undergraduate there. Miss Hoppin was her pupil at the college, and was later to follow her in teaching at the Normal School at Ypsilanti, Michigan. In a letter to Mr. Putnam, Normal historian, Ruth Hoppin described Miss Allen as a woman of few words, common sense, and strong convictions; a "ready writer, original and humorous."

During her last two years before graduation, Miss Hoppin taught in the preparatory department of Oberlin. Following graduation, she taught for two years in the Young Ladies Seminary at Jerseyville, Illinois. Four pressed plant specimens from Jerseyville survive in the E.M.U. Herbarium at Ypsilanti.

In 1858 she became preceptress of the Three Rivers Union Schools of which William H. Payne was principal. Professor Payne later organized and first filled the chair of "The Science and the Art of Teaching" at the University of Michigan at Ann Arbor. In a letter, Miss Genevieve Walton, librarian of the Michigan State Normal College, wrote, "May I suggest that Miss Hoppin's close acquaintance and work with William H. Paine [sic], who was one of our great American educators, must have given her a feeling for our great educational problems which few women of her time—or even later—possessed."

Excerpts from "Some Souvenirs of My Professional Life" by Professor Payne delightfully describe a typical village school of the period and also of a teacher' institute, which at that time was being first used effectively in Michigan by the state superintendent of public instruction, John M. Gregory: "In the early summer of 1858 I was elected principal of the Three Rivers school, with my wife as my assistant, at a joint salary of seven hundred dollars. We trundled our way into the pleasant village by the stage coach from Kalamazoo. As we entered the town, the most conspicuous sight was a narrow two-story brick building which we easily guessed to be the scene of our professional labors, and from the array of tubs, buckets, mops and brooms in front of the house, we drew the further inference that the beginning of our labors was near at hand."

[8]Article, "Professor James Dascomb," Oberlin Review, 1880.

The ardent faith of that era in education was expressed by Professor Payne: "In the State at large a new spirit was abroad. The university was calling young men to the higher intellectual life. By a process of gradual descent the lower schools caught the wholesome infection, and there followed the transformation of private schools and academies into public schools of the high school or secondary type. The public school system was in process of formation, a living organism with brain, central ganglia and minute nerve cells."

To awaken a local interest in education Mr. Payne invited State Superintendent Gregory to conduct a teacher's institute at Three Rivers. Accompanying Mr. Gregory came Professors Olney of Kalamazoo, and Sill and Welch of Ypsilanti. Taking a prominent part in the institute was the young woman from Oberlin, already bearing a local reputation as a teacher and disciplinarian. In her address there, published in the *Western Chronicle* for May 21, 1858, she "pleaded for apparatus for explaining and illustrating what she would teach. She decried the naked walls and pleaded for slates and blackboards, for map and picture making, and valiantly flew in the face of Providence by denouncing the ferule and the fear-inducing methods of an educational period which compelled children to swallow with fear-driven speed whole chapters which they could not understand. At this time Miss Hoppin adopted many homespun or as she termed them, school spun methods. The story goes that having no 'orery' she placed a redheaded boy revolving in the middle of the room as a center of light and heat and then set a sufficient number of smaller boys running around him to represent the annual motion of the planets."

It must have been during these early years, in the interaction of teaching and learning, that she formulated the convictions to be expressed years later, in an article written for *The School,* "Cultivation of the Power of Attention and Study," from which the following excerpts are taken:

> Remember at the outset it is quite as much your business to train them [the students] to correct mental habits as it is to teach them to read and to reckon.
>
> A judicious observance of a few rules will be of the utmost help. Keep every little mind, every little hand, occupied with the work you have set them to do. Have a systematic plan for all the work, all the play, done in your school-room. Have your plan written out, and hold both yourself and your pupils strictly to it.
>
> Have a time for relaxation, for recreation, and have all the relaxation, all the recreation, in its appointed time. Have each exercise practiced, each lesson studied, as strictly by programme as you would bring on your recitations.
>
> At each change in the programme tell the different classes what they are to do during the next division of time. If they need material to work with, distribute it at the beginning of the exercise; gather it up at the close.
>
> A programme prepared for a primary school might be something like the following:

	Recreation	
A. Print words.	Recreation	B. Read.
B. Print words.	Recreation	A. Read.
A. Make figures.	Recreation	B. Number.
B. Make figures.	Recreation	A. Number.
A. Copy drawing.	Recreation	B. Draw.

B. Copy drawing	Recreation	A. Draw.
A. Pile blocks.	Recreation	B. Spell.
B. Pile blocks.	Recreation	A. Spell.

Recreation of some kind will work down the super-abundant animal life, and rest the weary limbs, so you have a right to expect quiet and attention when you wish it.

As the pupil advances in maturity, his work should be made to correspond, but at no time should there be any irregular or haphazard effort. The rule that the school is sacred to school work, if well carried out, would do much to establish habits of attention and study. As a child becomes old enough to aid itself with books, you will need to direct it in their use. Correct methods of recitation will generally lead to correct modes of thought, but some extra guidance will be needed in the ways of lesson getting. A wise teacher gives this rule for recitations: Consider every lesson a failure that does not hold the attention of every pupil, and here are more like unto it. If, owing to weariness or to outside distracting influences beyond your control, you cannot hold the attention of your class, dismiss the recitation for the time.

Continue no exercise or recitation long enough to produce satiety.

Vary your programme enough to prevent monotony.

Often the recitation is a means of drawing off the attention of those at their desks, who should be studying. This should be discouraged, whether the fault lies at the door of the teacher, the pupil, or both.

A word as to the value of oral teaching as a means of cultivating the habit of attention and study: No one who has observed the effects of first-class oral instruction will dispute its power over the attention, but I do not believe that it is calculated to train children into habits of study. Those who have been trained by the former are quick, keen, but are not disposed to work out the hard things for themselves; neither are they capable of continued and sturdy thinking. In early childhood the oral method should predominate, and the use of text-books be gradually introduced till they take precedence, and finally the mature man can do his work without the aid of the living teacher.

Those who teach country schools, and have perhaps fifty-six classes, though only forty pupils, will ask how they are to get their work into any programme, and control the studying and the recitations.

It is the lack of all planning and controlling in these matters that has given these innumerable classes to our country schools. The disease is not so hopeless as you may suppose. I know not how it is now, but in the olden time the work of the little ones was put into one corner of each half day, after which the poor things were expected to keep still and be good, though not employed at any work. It is to be hoped that now they are better looked after, and that the exercises of the older and younger pupils are duly alternated through each session. The advantages of such alternation will be seen at a glance.

Why are so many of our pupils, of ourselves even, such miserable wool gatherers. . . ?

If we would think of one subject five minutes, we find ourselves running off on to a dozen that we do not wish to think of. The boy, in studying his geography, mingles cities, capes and kites, promontories, playthings, and playmates in his mind, in the most wonderful confusion. The girl, as she cons her history, mingles with the events she would memorize half of those of her own life, and many of those of her companions'. . . .

Is there a way to break ourselves of these miserable wanderings? I believe that any person, with good bodily and mental health, and an average amount of will, may in a measure become master of his own thoughts. Let him sit down to some study that requires a full play of the powers of abstraction and attention. The first moment he finds himself wandering, let him say to his erratic mind, as to

> the froward child, 'Back to your place!' Let him bring eyes and ears into subjection to this one purpose of controlling his mind. Let him repeat the process just as often as the mind wanders. At first such efforts will scatter and divert rather than concentrate his thoughts, but it will not be long before these efforts will bring a desirable reward.
>
> Much light reading, and that which appeals to the imagination only, is almost sure to weaken our power of fixing the attention, and the same may be said of the desultory reading of weighty authors.
>
> If we who have left school would not lose our power of earnest thought and severe study, we must see to it that some portion of our time is so employed as to test our higher powers.

At first the opinions expressed above may seem overly severe compared with our present day methods, or lack thereof, but a closer look shows them to be coupled with an understanding of and concern for the welfare of her pupils—notice all those "recreations"—which demanded even more of the teacher. These qualities were to make her much loved and honored in her field.

Following the period at Three Rivers, she was for three years preceptress in the Ann Arbor High School, Ann Arbor, Michigan. The chronology here seems a little obscure, as the exact date of her going to Ann Arbor is not mentioned, and one year seems lost. Of those three years at Ann Arbor this writer could find no more than mere mention, other than the following item from a *News Reporter* of 1865 (Three Rivers?) which said, "Miss Hoppin, our former most acceptable teacher, is to return next term as preceptress after an interim of three years as a successful teacher at Ann Arbor, where she attained success most unusual."

She apparently, however, did not return to Three Rivers, being instead invited, at the age of thirty-three, to become preceptress in the Michigan State Normal School at Ypsilanti.

The title "Preceptress" carried with it special responsibility for deportment and character development, denoting an older or superior practitioner who undertook the tutoring of the neophyte. She was, in fact, first a teacher, then a counselor. The position was to evolve and become later separated from teaching in the position of dean of women, with emphasis on rules and regulations, discipline, and social counseling.

Miss Hoppin assumed her new duties in the fall of 1867.

Classes were in those days taught in the "one and only building" (Phelps, 1951), a three story structure described at the time as follows:

> The building is of brick, finished with stuccowork, three stories in height, with a basement for furnaces and is divided into a model school room, with entries, reception, library, and recitation rooms and entries; a Normal School room in the second story with similar arrangements, and a large and spacious hall in the upper story. (Isbell, 1971, p. 11)

The sciences "were not separated into distinct departments. They were all taught by the same teachers. . . ." "Botany was assigned to the preceptress, who also taught literature and history. Botany was popular in those days, and was considered the one science especially fitted for the feminine mind. The first botany courses were systematic, but in 1879 structural botany was introduced" (Phelps, 1951). Miss Hoppin also taught arithmetic at times.

An Englishman, visiting the Normal at that time, wrote a charming description of the school, and of Miss Hoppin's class.

> I looked forward to the next class with additional interest, for I was informed that it would be conducted by a lady-professor, who, next to a "sweet girl graduate" is in English eyes the *rarissima avis* of the scholastic world.
>
> The room was very spacious, and the professorial desk was burdened with flowers, the raised platform was knee-deep in them, and they lay scattered in profusion on the students' seats.
>
> "Some festival, this, I suppose—isn't it?" asked I of a young lady.
>
> "Oh, no," with extreme wonderment at my simplicity.
>
> "What is going on, then, pray?"
>
> "Only 'our botany class,'"
>
> "Oh!"
>
> "Only 'our botany class'" soon set to in earnest, for they waste but little time here in their changes of work, and the lady-professor began to discuss her subject in a manner that gave me keen enjoyment, and deeply interested her students. With a natural and easy delivery, she pleasantly told us all the wonders of fungus life, of the marvellous beauties of mouldy secretions, of the exquisite fabrication of Lichen moss, of the spontaneous growth of the mushroom, and of the dainty beauty of mildew. This led to an animated argument on the part of the students as to the exact origin of that pestilence, "rust," upon ears of wheat, which would have been worthy of a hearing at a "debating night" of the Agricultural Society in Baker Street.
>
> Then we wandered through a pleasing maze of *Algae,*—associated in my mind with the idea of slimy vegetable marine reptiles—but which under this lady's treatment turned out to be very beautiful works of creation; and finally we—that is, they—talked the matter over *de novo* and ferreted out a dozen fresh, interesting incidents.
>
> I was much astonished at the lady-professor's topographical knowledge, for she seemed to be able to tell the students where to go for everything. There cannot be a lane or a field within ten miles of Ypsilanti with which she is not familiar, where she has not dug for her floral treasures. (Bigsby, 1873)

Throughout her life, beginning, even before her journey east for better educational opportunities, with her childhood determination to become a teacher, and continuing through to her last years in Three Rivers, teaching and learning were inseparably linked. "Teaching was her gift, her life work, her greatest delight" (Reed, 1903), and its corollary, which kept her gift fresh and shining, was learning and study.

A former student, Eliza Trump Reed, wrote of the Ypsilanti years, "During this period she was more student than ever. In the summers she tramped the meadows and woods from the southern border to Lake Superior adding much to the knowledge of the flora of the state. Several summers were spent at Harvard and in the study of eastern flora—especially sea-weed and aquatic plants." At another time Mrs. Reed wrote, "She hired fishermen and went out to the coves and islands to secure her own specimens making most delicate and beautiful drawings of what she discovered under the microscope. It was thought this close work permanently injured her eyes."

Mrs. Reed went on: "With a most wonderful memory she was an authority on all historical subjects, but her rare talent lay in scientific research in Botany and Biology. She knew all the flowers by scientific names. . . ." ". . . The flora of the entire United States from Maine to California from

Dakota to Florida had literally been gathered by her own hand. She did not hoard her wisdom but gave to all who came in contact with her.

"Miss Hoppin's work at the Normal was greater than that of a mere instructor. By slow painstaking progress she made for herself the reputation of being the finest botanist in Michigan and a distinguished teacher of history."

She herself wrote "Several summer vacations were given to study, one to Botany at Harvard, one in the scientific laboratory at Annisquam and one to travel in Europe."

Pressed specimens at Eastern Michigan University bear witness to those summers of study, as well as to faithful collecting in the vicinity of Ypsilanti and in her home country around Park and Three Rivers. During the years 1867 to 1870, surviving specimens come only from the areas around Ypsilanti and Three Rivers. In 1871 there are some from Cohasset, Massachusetts, and Fayetteville, Vermont. The Fayetteville specimens, being of cryptogams, seem to indicate a course in the same. There is one from Hingham, Massachusetts, in 1872, and from Medford, Massachusetts, in 1874. In 1875 came the glory of a summer trip on the Continent—two specimens from Heidelberg Castle, a little *Adiantum* from the ruins of Pompeii, and a *Convolvulus* from the Palatine Hill at Rome, accompanied by a handwritten note to an unnamed pupil:

> This pretty Convolvulus runs wild in many parts of Europe. This specimen was gathered on the Palatine hill, Rome, Aug. 6, 1875, by your teacher. This hill you remember is now occupied by the buried palaces of the Caesars. Acres of palaces are here buried. Other buildings have been erected over them and orchards and gardens are growing above them today. It was there I gathered this flower. Excavations are going on beneath, but do not much interfere with the growths above.
>
> It is only recently that the excavations have been commenced, but acres of these subterranean rooms are now accessible.

Underneath the five-inch piece of vine, with a brown flower at its tip, are the words, "From your teacher, Ruth Hoppin."

1877 found her by the Charles River, Cambridge, Massachusetts (that must have been the summer at Harvard), and at Manchester and Magnolia, Massachusetts, and Round Lake, New York.

In 1878 there was apparently a Grand Tour of Michigan, with the names of Little Traverse, Petoskey, Reed City, and Ludington appearing along with the more familiar Bangor, South Haven, and Three Rivers. However, there are also some algae specimens from Nahant, Massachusetts, dated August, 1878. I imagine her walking the beach at Nahant, the sea wind wisping her drawn-back hair, holding her long skirts out of waves' reach, picking the sieve-like *Agarum* from the tumbled wrack, or wresting a *Fucus* from a rock.

There is even, in December of that year, an American Mistletoe, *Phoradendron flavescens,* from Kentucky.

It was in this same year, 1878, that she was awarded an honorary M.A. from her *alma mater,* Oberlin.

Such specimens as we have from 1879 are from Michigan, but in August, 1880, she collected a little sandwort, *Arenaria serpyllifolia,* on Cape

Ann, Massachusetts. Where on Cape Ann did she collect it? Perhaps along what is now Rockport's North Beach? Did she walk among the rugged boulders and scrubby oaks of Dogtown, above Rockport?

The labels arouse other questions. Did she always collect these specimens personally, or were they sent to her by fellow botanists, as the February, 1878, plants from California almost certainly were? Here, however, she gives credit to a Mr. Hinton. Most of the others contain only notations in her own handwriting.

The years at Ypsilanti, then were filled with teaching and with study, with writing, and with community activities. She was on the first Women's Library Board in Ypsilanti, in the capacity of first vice-president. That she gained the respect and affection of her pupils and associates may be seen in tributes paid her when she left, in 1881, to assume the chair of Botany and Biology at Smith College. An item in a *Normal News* of that year says, "As a testimony of high regard the students presented her a costly microscope. Miss Bignell, of the senior class made the presentation, and Miss Hoppin feelingly responded. On the next Friday the ladies of Ypsilanti gave her a reception at the residence of Jerome Walton."

Upon receiving her resignation, the Board of Education (referred to, probably correctly, as the State Board of Education by Mrs. Eliza Reed) was moved to the following resolution:

> Whereas Miss Ruth Hoppin, for the past 14 years Preceptress of the State Normal School, has tendered her resignation in order to accept a position in the Faculty of an Eastern College, therefore,
>
> *Resolved,* that we, the members of the Board of Education, accept her resignation with unfeigned regret; that we are deeply sensible of the loss the Normal School is sustaining in thus releasing Miss Hoppin from so responsible a position,–a position to which she has brought accurate scholarship, rare tact and unusual executive ability; and in which, during this long service, she has merited the fullest confidence and esteem of this Board; and that we extend to Miss Hoppin our sincere wishes for her continued prosperity and happiness in her new field of labor.

Daniel Putnam, in his *History of the Michigan State Normal School,* describes the character of Miss Hoppin thus:

> As a student in her own special department, both in her early life and in her advanced years, Miss Hoppin had few equals and no superiors. Having chosen teaching as her vocation she sought to magnify her office. She taught, not merely because it was her duty and her business to teach, but because it was a pleasure to teach, and especially a pleasure to watch the unfolding of the minds of her pupils. She taught not alone to develop the intellectual abilities, not alone that students might know, but that the moral and religious powers might be aroused and excited to activity. She believed in the development of the whole being; she believed in helping the pupil to look beyond and above the materialism with which we are all more or less surrounded; and in which the young especially are very likely to become involved. She sought earnestly to make her own life an example and pattern for the young men and women whom she taught. Some characteristics of Miss Hoppin could be known only to her most intimate associates. She was generous almost to a fault, helping those who needed help, and lifting up those who needed to be lifted up, giving strength and courage to those who had especial need of strength and courage.

From this atmosphere of warm friendship and admiration, Ruth Hoppin went, at the age of forty-seven, to Smith College, Northampton, Massachusetts. It may be surmised that contacts leading to her invitation to that position may have been made during those summers of study in the East.

Her appointment, in the records of the college, was designated as "Teacher of Physiology, Biology, and Botany," and carried with it a salary of $1250.[9]

Smith College, founded by Miss Sophia Smith of Hatfield, Massachusetts, had been established as an "institution for the higher education of young women, with the design to furnish them means and facilities for education equal to those . . . afforded . . . to young men." Nondenominational, the college nevertheless had a strong religious emphasis, as had the Oberlin of Miss Hoppin's earlier years. It was "not intended to fit woman for a particular sphere or profession, but to perfect her intellect by those methods which philosophy and experience have approved, so that she may be better qualified to enjoy and to do well her work in life, whatever that work may be."[10]

No preparatory department was connected with the institution. To enter the First Class a young lady "must pass a satisfactory examination in the Latin and Greek Grammars (Harkness and Goodwin preferred); Harkness's Latin Prose, First and Second Parts; the Catiline of Sallust, (or four Books of Caesar); seven Orations of Cicero; the first six Books of Virgil's Aeneid; four Books of Xenophon's Anabasis; three Books of Homer's Iliad; Jones's Greek Prose, first eighteen exercises; Arithmetic; Loomis's Algebra (or any standard University Algebra), through Quadratic Equations; four Books of Geometry; and so much Grammar and Rhetoric as will enable the student to present a correct letter or simple essay."[10] Equivalents would be accepted.

Satisfactory testimonials must also be presented concerning personal character.

The course of study extended through four years, combining required and elective studies. Recommended hours were not less than thirteen, nor more than sixteen per week.

The calendar for the school year 1881-1882 was set up in three terms: Fall Term of fourteen weeks, ending December 21; vacation of two weeks; Winter Term of twelve weeks, ending March 29; vacation of two weeks; Summer Term of ten weeks, ending June 21; vacation of twelve weeks; Fall Term beginning September 15. Miss Hoppin was responsible for the following schedule of teaching:[10]

Fall Term:

First year class: Lectures on Hygiene, one hour a week, (required).
Second year class: Lectures on Botany: Laboratory Practice. Two hours a week. (elective).
Junior year: Lectures on Biology, with Laboratory Practice. Two hours a week. (elective).
Senior year: Botany, Laboratory Practice. (elective).

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[9]Unpublished, undated manuscript by Helen Choate, "The history of the Botany Department of Smith College, 1875-1950."

[10]Smith College Official Circular, 1881.

Winter Term:

Junior year: Lectures on Physiology, with Laboratory Practice. Two hours a week. (elective).
Senior year: Zoology.–Practical Work in Conchology. Two hours a week. (elective). Botany.–Two hours a week. (elective).

Summer Term:

First Year: Lectures on Botany, with Practical Work. Three hours a week. (elective).
Second Year: Botany, Laboratory Practice. (elective).
Junior Year: Zoology, Laboratory Practice. (elective). Botany. Laboratory Practice. (elective).
Senior Year: Botany.–Laboratory Practice. (elective).

In addition to her teaching, she had a part in the social culture of her pupils. It was the wish of the Trustees, as stated in the circular, "to realize, as far as possible, the idea of a literary community, in which young women may not only enjoy the best facilities for intellectual discipline, but may also attain a social refinement and culture, which will enable them to feel at home in good society, and conduct themselves with propriety and grace in any sphere of life. To realize this idea more fully, the plan has been adopted of erecting a number of smaller dwelling-houses around a central academic building. Each forms a separate establishment, with its own dining-room, parlors, and kitchen. A lady is in charge of each of these households, to direct its social and domestic life. In this manner young ladies may enjoy the quiet and comfort of a private home, and, at the same time, the advantages of a great literary institution." Miss Hoppin resided in the Washburn House, of which Miss Ellen W. Abbott was in charge, doubtless assisting in the direction of that house.

Into this atmosphere of classicism, this "literary community," came the Ruth Hoppin of pioneer beginnings. In her native Michigan, friends had been warm in their praise–"generous to a fault," "she knew the plants by their scientific names." Cooler voices spoke in the first-hand remembrances[9] of two Smith students of the class of 1885:

> I knew Miss Hoppin quite well as she lived in the Washburn House and sat at the head of our Freshman table. A kindly elderly woman really interested in us, although she had apparently never known our like before. She gave lectures on Hygiene, required for Freshmen. In the spring term I took her course in Botany, but recall next to nothing of it. I can only remember that she allotted each member of the class a special project for observation. I remember spending a good many afternoons on the back campus studying 'Bilateral Leaf Symmetry' if that makes any sense.
>
> –Anna A. Cutler

> I remember her [Miss Hoppin] vaguely,–a tall angular, rather unprepossessing woman. I had a course in Botany with her in spring term of Freshman year. The only remembrances of it is hours spent at the microscope and the final examination in analysing an unfamiliar plant which proved to be Brunella Vulgaris, and my surprise at getting a high grade in the course. If I am not mistaken she gave the course in Freshman Hygiene, stressing the kind of clothes one should wear and the food one should eat–a rather general unscientific course. One of my classmates made fun of the course in some lines:

A barbarous relic is your pie,
So great men say and so say I.
The gastric juice does not contain
The element pie crust to strain.

—[Ruth Barker] Franklin

Was this dimmer personality described here the result of the incipient illness which was to make her stay at Smith a short three years, or did the coolness of this different atmosphere contribute to her illness? In any case, in the middle of her third year at Smith College she was compelled to resign, before the summer term. The President's report of 1883-84 stated, "A little later Miss Hoppin was afflicted with an organic disease which led her physician . . . to insist" that she resign. She herself, years later, in her letter to the Normal historian, Daniel Putnam, said simply, "In the middle of my third year there broke down in health."

There followed five years of rest and recreation and travel. She spent several years in Missouri and Texas, according to several sources, part of the time (1887-8) as collector for Harvard's Agassiz Museum of Natural History. She herself, in a report to Azariah Root of Oberlin, written in 1894, said briefly, "During 1888-1889 in S.W. Missouri collecting cave specimens for the Agassiz Museum." Mrs. Reed wrote, ". . . ill health compelled her to go south. Here in rubber boots she continued her study of plants, exploring caves, studying plants and lower forms of life." Her historian, Sue Silliman, in the same context wrote, "She spent one year in the scientific laboratory at Anisquam. [Did this perhaps refer instead to an earlier summer of study?] As a collector for Harvard University she discovered odd specimens of fish which were sent to the Agassiz Museum of Natural History at Cambridge. One species of fish was named for her—'Hoppini.' Miss Hoppin was also a reporter to the Smithsonian Institute at Washington." In a different account Mrs. Reed said, "—some new specimens, found in the caves, bear her name (Hoppineas)." In answer to inquiries sent by the writer to the Agassiz Museum and to the Smithsonian Institution, only the former found a record of her by name. A current search of lists of cave fishes of the Southwest does not reveal such a species. Dr. Reeve Bailey, Curator of Fishes, University of Michigan Museum of Zoology, has been unable to confirm that any North American fish was ever named for her.

The Silliman account stated that "later she travelled in Europe and on the Continent." Mrs. Reed, in her article "In Memoriam" wrote "Miss Hoppin gleaned much from travel. With her pupils in English History she literally visited again the historic spots of Great Britain from the days of the invasion by Caesar to the days of Victoria. With her French or German pupils, she visited the homes of the Masters in Art and Poetry, on the Continent." Did this reference pertain to these years of "rest and travel," to the earlier years at the Normal, to the pupils of her late years, or was it even an enthusiastic description of her vivid teaching? A letter written by Ruth Hoppin from Stratford-on-Avon, realistically describing Shakespeare's home, was presented to the Three Rivers Public Library for its historical collection by Mrs. H. P.

Barrows, president of the Ruth Hoppin Class (Silliman, 1926, p. 550, footnote). These collections are not at present available.

In 1890, at the age of fifty-six, she entered the University of Michigan at Ann Arbor to pursue literary studies. In her 1894 report to Oberlin College, she listed the "professional and other studies" taken up since January, 1888, as "Biology, History, English Literature and the French and German languages. Also the Anglo Saxon." She listed too a paper, "'The Revival of Learning in Its Relations to the Reformation' and 'A Pioneer History of S. W. Michigan"' in answer to "Books or Articles written or edited."

Her work at Ann Arbor "was taken up as a recreation but so earnest and thorough a student as Miss Hoppin could not read for recreation alone and in 1891 she received the degree Master of Arts, upon examination and regular graduation, in preference to the honorary degree offered her previously (Reed, 1903). According to Sue Silliman she had replied to the offer of an honorary degree for her research and contribution to science, "No, I shall write my thesis and take my A.M. in the regular way."

Following the achievement of the master's degree, she taught literature in the University of North Dakota, in 1892 and 1893. Finding the climate too severe and again in impaired health she returned to Three Rivers, which was to be her home for the ten remaining years of her life.

During these last years she was far from idle, remaining active and productive until almost the last. In 1898 she wrote Professor Putnam, "Since . . . [1893] my home has been in Three Rivers. Time spent mostly in teaching private pupils, and leading Women's Clubs." Her private classes were in Literature and History, and she gave as well much time to work in the Presbyterian church.

According to her loyal biographer, Mrs. Reed,

> In no other place in the world could Miss Hoppin have found such a host of tender, loving, devoted friends as made her last years happy in the little city of Three Rivers. Here in literary circles she was the counselor and highest authority, in church work she prayed and sang with those who had loved her half a century and who knew and appreciated the sweet pure christian character.

The homes of her sisters, Mrs. Reed and Mrs. Kellogg of Park were near at hand.

It was early in this period that she read her "Personal Recollections of Pioneer Days" before the Meeting of the Pioneer Society at Centerville, June 14, 1893.

During her last few years she was an invalid and blind. Although an operation for cataract in January of 1902 was successful, permitting her again to enjoy "current news and old classics," in the last year she failed rapidly. She died on April 1, 1903.

> Her casket covered with the flowers she knew and loved so well, waited in state from 1 to 3 p.m. April 3, 1903, in the Presbyterian church of Three Rivers, Michigan.
>
> A brief, beautiful tribute to her life and work was paid by her pastor, Rev. A. L. Toner, and the choir sang "My faith looks up to thee," "Lead kindly light,"

and "Nearer my God to thee" her favorite hymns. The sacred dust rests in the South Park cemetery, near her mother, sisters and other kin, whom she loved with an unselfish devotion. (Reed, 1903)

That so much of Ruth Hoppin's image survives across the intervening century, when lesser spirits passed without a trace, demonstrates her strong personality. Her life exemplified the great influence a gifted and dedicated teacher may have on her pupils, extending down the generations. Friends formed, after her death, the Ruth Hoppin class, to perpetuate her work and memory. Their papers are deposited with the Three Rivers Public Library.

There are sidelights, also, to the central theme of her life. A clipping from an unnamed newspaper, dated April 1, 1903, reveals a facet mentioned nowhere else.

Patriotic Old Lady Dead at Three Rivers
Miss Ruth Hoppin, Who Helped Equip a Regiment

Three Rivers, Mich., April 1—Miss Ruth Hoppin, aged 70 years, died at her home in this city this morning. She was a lady of rare literary ability and years ago had more than a state reputation in the education field. For fifteen years she was preceptress of the State Normal School at Ypsilanti. Of late her mind had been affected, owing to a loss of eyesight. During the outbreak of the Civil War she was the most active person in this vicinity in helping to equip the 11th Michigan infantry, which went from this place, and her regret was that she was not a boy that she could shoulder a gun in the defense of the flag. Several languages were at her command and her use of them was considered adept. She leaves no immediate relatives in this vicinity.

The finding of this newspaper clipping raised the question of whether any members of her family did serve in the Civil War. Consultation of the official record of the Eleventh Michigan Infantry showed no Hoppin listed.

She was, from her early teaching days, identified with the prohibition movement, doubtless reflecting her childhood terror of drunken Indians. Her "pleas for prohibition, sometimes in metrical form, were published by many of the Michigan newspapers of the day" (Silliman, 1926, p. 558).

Also published were articles on a number of subjects, including a rather humorous essay on "The Schoolmaster," in which she took some sly thrusts at her male counterparts, past and present, the teacher-pupil relationship in general, and the trials of a school administrator, and slipped in a startingly contemporary argument.

The school-ma'am thinks that the guardian of educational interests, and he to whom she is expected to look for the adjustment of her rights, is sometimes less thoughtful for her rights than he might be; that he might oftener use his influence in her favor. . . . Can she remember that he has ever said or done much to correct the public sentiment that prefers the untried, ill prepared boy to the experienced woman, and that gives to the boy double or thrice the wages that the woman can command? And are not his explanations of these unjust differences, many times, very poor excuses? It may not be in his power to right the wrong, but she feels that magnanimity does not require him to expend all his enthusiasm in defending the wrong. She comprehends the reasoning when told of the "law of supply and demand," but she can not reach up to the logic which says that *he* should have more wages because "he is expected to give more." Would she not like to have the public think her benevolent? And that other argument, that it is against nature to let women earn enough to take care of themselves. If they were raised above the necessity of marrying for homes, what would become of the housekeepers? She "cannot reason," but she–thinks! Was that man's wife some bright, true girl, who, without a thought of money, accepted him because she believed him to be "the only man in the world?" or did he marry some helpless Flora McFlumsy (her father recently suspended), who took him because she saw no other way of meeting the dry goods and bread and butter question?

This then, is what we have been able to piece together of the life of this unusual, gifted, courageous woman, of whom Professor Payne telegraphed the day of her funeral, "One of the noblest of women and the best of teachers."

It seems fitting, as a link between her concern and that of our own time, to conclude this account with her own of the appearance of a Michigan oak opening of that time, similar to the Prairie Ronde of her childhood, which was also the setting of James Fenimore Cooper's novel, *Oak Openings.*

> Much as I love those forest scenes, I have not words sufficient to give you any adequate picture of them. The fires had not run through the woods for a few years, so the wild flowers had been given full possession, and the underbrush, grubs, we called it, had not had time to grow up. The result was that the woods looked more like an old orchard than a forest. Roads wound at will among the trees, making the most graceful curves and pleasing turns. In early summer the grass was overtopped with wild flowers, surpassing in beautiful effects the most skillful landscape gardening and city park scenery.
>
> Blue lupines, variegated phlox, scarlet painted cups, purple and white erigerons, purple cranes' bills, blue spider worts, yellow cynthias, senecios and rock roses, tall golden Alexanders and white meadow rue, dainty galiums and coarse Solumbo [sic], medicinal lady slippers, Seneca Snake root and culver root, all these came on together or in rapid succession, commingling in the wildest profusion, and stretching as far as the eye could reach under the delicate oak foliage. Why try to describe earlier growths of violets, buttercups and anemones, or the later crowd of sun flowers, asters and all their sisters, their cousins, and their aunts? The now nearly exterminated fringed gentian then flourished in abundance.
>
> The farmers, in their eagerness to subdue the soil, have destroyed whole families of these harmless plants and have let in others, many of them not pleasing to look at, and much more hurtful than the native species. I see the day coming when there will not be a patch of forest where the child may see the flowers which charmed his parents' eyes. Like the buffalo, the deer, the wild pigeon, the whip-poor-will and the prairie hen, these, too, will soon be things of the past.
>
> The last pioneer will soon be gone and with him many of the native plants and animals will soon disappear.
>
> Truly, the history of the land and such surroundings are well worth being carefully written and preserved. (Hoppin, 1926)

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PRIORITY RANKING OF BIOTIC NATURAL AREAS

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INTRODUCTION–A BRIEF HISTORY OF WISCONSIN'S NATURAL AREA PRESERVATION EFFORTS

Wisconsin, long known as a pioneer in natural area preservation, initiated its efforts in 1945[1] when the Conservation Commission unanimously approved a resolution by Commissioner Aldo Leopold which created the Natural Areas Committee. Its duties were to "lay out a plan to acquire . . . a system of small areas representing the native vegetation of Wisconsin, including samples of woodland, marsh, bog, beach and prairie, to be held and used solely for educational and scientific purposes, . . ." The resolution included an appropriation of $5,000 for natural area acquisition, but once exhausted it was never renewed. During its seven-year existence, the Natural Areas Committee identified several outstanding natural areas such as Cedarburg Bog, Scuppernong Prairie, and Parfrey's Glen, which was later purchased from the funds appropriated.

The Natural Areas Committee was abolished in 1951 with the creation of its successor, the State Board for the Preservation of Scientific Areas. The Board was charged by statute to advise local, state, and federal agencies

[1]Minutes of Wisconsin Conservation Commission, February 13, 1945, pp. 23-24.

regarding the selection, acquisition, utilization, and maintenance of scientific areas. With a capable leader in ecologist John T. Curtis plus the enthusiastic support of the other member-naturalists, the Board established 16 scientific areas by the end of 1952 and 27 areas through 1953. The Board operated without a staff or budget.

The allocation of a budget in 1966 was responsible for a renewed vitality in Wisconsin's preservation program. Within several years the large backlog of uninspected natural areas was reduced, and additional potential scientific areas and a variety of nautral features were delineated and field-checked. More recently, the Scientific Areas Preservation Council, formerly the State Board for the Preservation of Scientific Areas, has encouraged and sponsored the field work for complete natural area inventories of nine southern Wisconsin counties in order to identify natural areas of both state and local significance.

Today, 22 years after the original legislation, natural area preservation in Wisconsin has progressed far and witnessed many changes. There are now 105 state scientific areas encompassing nearly 15,000 acres. The majority of scientific areas are on lands acquired for hunting, fishing, park, and forestry purposes by several agencies, most notably the Wisconsin Department of Natural Resources (DNR).

The Council has not been alone in its efforts toward natural area preservation. Nonprofit conservation agencies, especially the effective Wisconsin Chapter of the Nature Conservancy, and a variety of other private groups have been instrumental in locating and purchasing natural areas under circumstances where public agencies have been unable or slow to become involved. There are indications, too, that planning and administrative personnel in Wisconsin at the county and state level are becoming actively aware of the need to at least identify representative natural communities and features of the landscape.

Both public agencies and private groups dedicated to natural area preservation have been limited by a lack of money. Private groups have had to rely on donations to finance their projects, and until recently, only a token amount of money had been appropriated by public agencies specifically for natural area acquisition. A modern precedent was set, however, when $100,000 from the Outdoor Recreation Act Program (ORAP)[2] was earmarked for natural area acquisition by the Wisconsin DNR for the 1971-73 biennium. The Council, having the responsibility for recommending the top-priority tracts, planned that two or three areas could be purchased annually through judicious use of the funds.

In view of the limited acquisition funds, the need of an evaluation system became apparent even though Council and staff have utilized criteria to identify and select the highest priority areas for years on an informal basis. For nearly thirty years the Council and its predecessors have accumulated

[2]ORAP–Outdoor Recreation Act Program is a $200 million bonding program for land acquisition and development in Wisconsin.

inventory data on a large number of high-priority natural areas, many of which have remained under private ownership. From this backlog of natural areas plus those to be identified in the future, a relatively few will be selected as acquisition candidates. In addition, there has been an increasing number of individuals and agencies requesting help in natural area evaluation. Fulfilling all the requests is difficult, but providing an evaluation system upon request would allow others to familiarize themselves with evaluation techniques.

A system designed for priority ranking of natural areas would be of benefit to Council and staff for 1) selection of the most representative example of a natural area type when several examples of the same type are undergoing simultaneous evaluation; 2) comparing the relative "value" of natural areas and natural features where such factors as disturbance, quality, diversity, etc., vary from one area to another; 3) forcing systematic analysis of tracts to consider each factor as objectively as possible.

THE EVALUATION SYSTEM

This is a preliminary approach to a priority ranking of natural areas,[3] and it emphasizes the evaluation of vegetative characteristics as the basis for comparing areas and establishing priorities. Additional features such as geological or archaeological sites, animal species preserves, and other natural features of the landscape deserve recognition in natural area evaluation. Council staff will continue to seek the advice of numerous specialists as necessary so that top-priority zoological, archaeological, and geological sites receive adequate representation within the scientific area system.

This evaluation of natural areas does not consider scenic beauty, ease of access, potential for enjoyment of nature, availability of public facilities, or hazards to visitors. Public enjoyment, safety, and convenience factors are of important consideration in parks and other less restricted areas but of lesser significance in natural area evaluation.

The ranking system is founded on a systematic analysis of the areas to be ranked based on criteria which are grouped into four categories: 1) determinants of natural area value (biological characteristics), including quality, commonness, and community diversity; 2) physical characteristics and use value, the former including size and buffer considerations; 3) degree of threat; and 4) availability. Areas of both public and private ownership can be ranked with this system.

Factors concerned with management and protection of natural areas, although vitally important for long-term maintenance of an area, were omitted from the ranking. Examples include unauthorized use by snowmobiles or other vehicular traffic, the cost of fencing, enforcement, or boardwalk construction, and the time and energy needed for these. These factors often become problems after an area has achieved scientific area status, but they would seldom be of such importance that they would affect a decision regarding preservation.

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[3]The Scientific Areas Preservation Council utilizes the terrestrial plant community classification scheme of John T. Curtis in *The Vegetation of Wisconsin* (1959).

Although all factors need to be considered in evaluating the "value" of a potential scientific area, certain factors are more important than others. For example, consider quality of an area versus the presence or absence of a buffer zone. Quality is obviously one of the most important determinants of natural area selection, while a buffer zone, which increases the probability of more complete protection, is not instrumental to the existence of a natural area. To equalize these and other factors, a weighted system of point allocation was utilized in the ranking.

The weighting of criteria utilized in evaluating natural areas was determined by analysis of the reasons for which areas were established as scientific areas as well as the long-term goals of the Council. Both are related to the nature and distribution of the presettlement vegetation types in the state and their historical preservation and conversion to the existing types. The results indicated that of the eight factors utilized in the ranking, both quality and threat were of greatest overall importance and most often of primary consideration in an area's evaluation. They were weighted the heaviest. The remaining criteria in order of decreasing importance are: size and buffer, commonness, community diversity, availability, and finally, use value.

PROBLEMS OF A RANKING SCHEME

Ranking natural areas involves several problems, any one of which will influence the results. No one person has seen all of the areas to be ranked, and this problem is compounded by the difficulty in assessing an area in one visit. Council staff has found it necessary to investigate an area two or three times during different seasons to obtain a reasonable analysis of an area's features. No one should attempt to rank a natural area on the basis of another's report or without a personal inspection.

Secondly, the more factors involved in evaluating an area the more averaging there will be; thus the outstanding qualities and deficiencies will be masked. The perfect blend for an evaluation is one which uses the fewest criteria but most accurately reflects an area's worth.

Thirdly, there is the problem of obtaining a single and meaningful numerical score for each area evaluated taking into consideration the three disparate qualities: biological (and physical) characteristics, threat, and availability. A simple additive scoring scheme was discarded because it could equate two areas, for example, one of which was for sale and the other which was not available. Similarly, natural areas with high quality and not threatened, and low quality, threatened areas could be ranked alike. Multiplicative scoring has been suggested and appears to more accurately portray the relative "value" of natural areas. It was decided, however, that any scoring system which provided a composite score for the above characteristics, no matter how it was derived, masks the critical criteria relating to ultimate preservation by acquisition: availability and threat. The final scoring system retained separate scores for biological and physical characteristics, availability, and threat for quick and accurate comparison of areas.

Lastly, this system was developed to identify the best natural areas from a select group representing the best of known natural areas in the state. Evaluating the differences between natural areas in a select group proves more difficult than comparing natural areas with a wide range of differences. Other problems like the lack of reference materials on most areas and the occasional occurrence of personal preferences hinder objectivity.

USING THE RANKING SCHEME

The defined criteria under each heading should be systematically applied to an area to award points, but be aware of the point differences for the various criteria. Note that for those criteria which have only even points defined, the scorer may allocate odd numbers. This may ease the relative comparison of areas for some scorers. Great care should be taken in evaluating an area to avoid intermingling elements of different factors. Work with others who know the areas well and pool information to reduce emotional input.

For each area evaluated, sum the points allocated for quality, commonness, community diversity, size, and buffer. The higher the total the greater a natural area's "value." This total and points allocated for availability and threat can then be compared for each of the areas evaluated to rank them comparatively.

CRITERIA FOR PRIORITY RANKING OF BIOTIC NATURAL AREAS

I. Determinants of Natural Area Value (Biological Characteristics)

A. Quality—Quality is a ranking of an area based on the excellence of its main features as measured by 1) diversity of native plant or animal species, i.e., are the expected (modal) species present? 2) plant community structure and integrity; 3) the extent of significant human interference (disturbance) to the community. Disturbance includes logging, pasturing, development, fire, herbicides, water level change, ditching, etc., and it may be evidenced by exotic weedy invaders, loss of intolerant species, and increase of aggressive native plants. 4) The extent to which a community corresponds with our concept of the identified natural community as it existed before settlement.

Quality analysis of the different natural area types found in Wisconsin requires that different criteria be applied to each type. In all forests, for example, old-growth timber is a very important factor, while in certain forest types such characteristics as a rich spring flora, an overabundance of armed shrubs, and tree size class diversity are important in evaluating quality. It is beyond the scope of this paper to examine the characteristics of the different community types as well as what constitutes a significant disturbance to a particular type, and it is expected that anyone ranking natural areas is well familiarized with the region's ecology.

Point Allocation	Points
Highest Quality—area approaches the ideal community type; no disturbance or disturbance not visible.	10

High Quality—evidence of very minor disturbance 8

High Quality—at least one type of more obvious disturbance 6

Moderate Quality—one or more types of disturbance to community is obvious and community integrity threatened. (Area is of local significance and may be of state significance in the future.) 4

Low Quality—disturbance with resultant loss of the biotic community structure. May still have value as species habitats. (May now or in future be of local significance, but without the presence of nonbiotic features, the area should be dropped from consideration for state significance.) 2

B. Commonness—Commonness is a measure of the importance of a natural area type derived by evaluating the acreage of the type in presettlement vegetation, the method of historical conversion of the type and its resultant degree of destruction, restricted nature of occurrence, the presence of rare or endangered species, and the amount of the type in the present landscape of the region. Commonness indicates the comparative evaluation of natural areas rather than a comparison between natural areas and the remaining landscape. Using the latter definition, one would be required to rank all natural areas as very uncommon. Natural area types like white oak—black oak forest in southern Wisconsin and a northern mesic forest are ordinarily viewed as being common, whereas a mesic prairie and a coastal beach community are very uncommon.

Point Allocation Points

Very Uncommon—low acreage in presettlement vegetation and present vegetation, nearly complete conversion of type, restricted occurrence, the presence of two or more rare or endangered species, or the only known location of a nonbotanical feature. 6

Uncommon—moderate amount of type in presettlement vegetation and/or partial conversion of type, moderate amount of acreage of type in present landscape of region, no known rare or endangered species. 4

Common—frequent to abundant in the present landscape, the type has increased since the advent of white settlement, or an adequate representation of the type within the scientific area system. 2

C. Community Diversity—The number of plant community types or other natural features within a tract is defined as community diversity. It is desirable to include within a natural area more than one biotic community type or natural feature to protect a continuum of types expressed across different soil, topographic, bedrock, slope, and water regimes. This allows protection of a greater range of habitat types and their biotic members, some of which may not necessarily be confined to a single community type. It also greatly increases the scientific and educational use value over that of a single isolated community or feature.

Point Allocation	Points
Great Diversity—four or more community types or features	5
Moderate Diversity—two or three types or features	3
No Diversity—single community type or feature	1

II. Physical Characteristics and Use Value

Size and Buffer are scored together.

A. Size—The minimum recommended size for plant community types, assuming adequate buffer protection, varies according to the nature of the type. A minimum size for woodlands is near 40 acres, while a remnant prairie 5 acres in size is sufficiently large to maintain its community integrity. For many natural area types, especially those which have been severely diminished in total area and those which have extreme geographical limitations, it is now necessary to totally preserve the remaining examples, regardless of size.

B. Buffer Zone—A buffer zone is deemed adequate if it will afford protection to a natural area from the direct and indirect activities of man and from the elements. The adequacy of and need for a buffer zone are determined on an individual area basis considering the following variables: the vegetation type in the buffer zone and the size of the natural area; the nature of the natural area's boundary (road, river, fence, or not defined); and the compatibility of adjacent land use, land ownership pattern, topography, and expected degree of encroachment.

Point Allocation	Points
Greatly exceeds minimum size, excellent buffer, no threat of encroachment	8
Adequate size and buffer	6
Adequate size, inadequate buffer	4
Inadequate size, adequate buffer	2
Both inadequate	0

C. Use Value—Use value is an indicator of the value of an area as measured by the amount of current and potential educational and other use the tract may receive. Use is intended to include formalized class and instructional activities, research, and informal nature use. The latter would include tours by various conservation-oriented groups and individuals. For use evaluation, consider proximity to a metropolitan area and major colleges and universities, adaptability to such use, and the ability of the area to absorb use without deteriorating.

Structured educational and individual use of natural areas is extremely important as a learning experience. However, educational experience is secondary to preservation for the future, hence its low point valuation here.

Point Allocation	Points
Outstanding value—annually used by several schools or groups for both casual and structured activities; near metropolitan areas; extensive field station use or potential for extensive use	4
Intermediate to high value	2, 3
Moderate value	1

III. Degree of Threat

Degree of threat is, unfortunately, a very important consideration in evaluating natural area priorities. Were there sufficient funds available to protect all of the choice natural areas, and better public understanding of the need, threat would be of little consequence in a priority rating. Because only limited funds are at hand, those areas that are threatened must be acted upon first in a crisis-by-crisis approach.

Threat may be defined as a rating of an area's security in respect to the maintenance of the structure and integrity of its plant communities and other natural features. In this evaluation, threat for the foreseeable future is considered.

Points to consider are

1. Region of the state, land use patterns in the vicinity, local and state zoning or their lack.
2. Potential of the tract for development, construction, drainage or impoundment, grazing, lumbering, windbreak planting, reforestation, plant introduction, etc.
3. Vulnerability to such projects as sewer, highway, pipeline, mining, or other noncompatible use.
4. Owner attitude toward preservation.
5. Possibility of increasing taxes, especially on lakeshore property.

Point Allocation	Points
Threat is imminent; main features currently being developed or destroyed	10
Threat is imminent to portion of main features	8
Threat is moderate; development probable in future	6
Disturbance encroaching upon area	4
Little threat—destruction unlikely	2

IV. Availability—Availability is an assessment of the probability that an area will come under protective ownership, and it is evaluated by analyzing the following factors:

A. Cost of purchasing or protecting an area (lease, easement, etc.) with or without funding aid. Consider complexity of ownership.

B. Will the owner sell? To the state? Consider the main features of a tract as an entity and not small parcels of the whole.

C. An area may be considered for donation by its owners.

Point Allocation	Points
Available—offered as donation or owned by cooperating public agency	5
Available or at near appraisal cost, within an approved land acquisition boundary, or possible candidate for donation	4
Probably available at high cost	3
Availability in doubt—perhaps in time	2
Not available or available by condemnation	1

One caution is appropriate here. This system is not designed to finalize an area's priority ranking, but instead to indicate its comparative ranking when analyzed along with other natural areas. Ideally this ranking scheme will provide an aid to the evaluation and selection of top-priority natural areas. And, following the example of all viable systems, if it is expected to become increasingly useful, its evolution will see periodic revision and reevaluation.

ACKNOWLEDGMENTS

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Criteria for Selection and Quantitative Evaluation of Natural Areas. The Nature Conservancy. Washington, D.C. (1 p., unpublished)

Curtis, John T. 1959. The Vegetation of Wisconsin. University of Wisconsin Press, Madison, Wisconsin. 657 pp.

Read, Robert H. 1972. Factors to Consider in Determining Quality of Major Plant Communities. (4 pp., unpublished)

Schwarzmeier, Jerome. 1972. Preliminary Inventory Scale Waukesha County Parks. Waukesha County Parks and Planning Commission. Waukesha, Wisconsin. (unpublished)

Schwegman, John E. 1972. Natural Area Evaluation Sheet for Determining Priority of Land Acquisition Projects. Illinois Department of Conservation. (3 pp., unpublished)

Wisconsin Conservation Commission. 1945. Minutes of February 13 meeting, pp. 23-24.

Zimmerman, James H. 1972. (An untitled treatment on evaluating flora and fauna for the Dane County, Wisconsin, wetland inventory. 6 pp., unpublished.)

SEASONALITY AND SPORE TYPE OF THE PTERIDOPHYTES OF MICHIGAN

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Interest in the structure of spores has increased during the past several decades, in part because of the expansion of the field of palynology with its valuable contributions to floristic and vegetational history, and in part because spores have been found to have value in determination of taxonomic relationships. There has been less emphasis on the ecological adaptations of spores, and indeed much of what has been written in recent years is almost purely descriptive, lacking any pertinence to what possible biological functions the different characters of spores may have. In this paper we wish to present some facts about the relationships of different spore types to the time of their discharge, and to interpret their possible adaptive significance.

Structurally there are basically two over-all shapes of fern spores: the tetrahedral or radiosymmetrical and the bilateral or bisymmetrical. In the former, the "scar" or laesura is trilete, appearing like three spokes radiating from a center, and in the latter the laesura is a simple line. Usually a given species of pteridophyte has only one type of spore. For example, all clubmosses, grape ferns, and cliff-brakes have tetrahedral spores; and all wood ferns and bladder ferns have bilateral ones. The spore wall is referred to as the exine or exospore and it may have various patterns of sculpture. There may also be present an extra jacket, the perine or perispore, which appears as a more or less irregular covering over the exospore and which is readily destroyed, as in fossilization (Selling, 1946).

Functionally, there are several distinguishable types and these are what we are concerned with here. The typical fern spore, once released, is carried by the wind to an appropriate spot where it germinates. Germination usually takes about a week in suitable habitats, which are usually exposed mineral surfaces (such as shady road banks, stream banks) or rotting logs. Most spores can survive in a resting state for a number of years. The spores of many species can be grown easily by placing them on simple mineral media or even on wet flower-pot chips. A certain amount of light is required; below a certain level, a curious filamentous growth habit is assumed, but if there is sufficient light, the gametophyte is a green, plate-like, and usually heart-shaped thallus.

There are three major variations in structure and function from the typical spore: (a) heterospores (*Isoëtes* and *Selaginella*); (b) green spores; and (c) spores which cannot be germinated the ordinary way. We are not concerned here with heterospores, which are characterized by endosporic, parasitic gametophytes, and vast differences between the micro- or male spores and the mega- or female spores, the latter extremely large and containing large amounts of food for the embryo. Green spores are those which contain chloroplasts rather than proplastids, are thin-walled, and germinate in one or two days. They are incapable of surviving long periods, unlike typical spores; usually if dried out for even as short a time as a week, most if not all will die. A most interesting and little-understood type of spore is the one which cannot be germinated in the ordinary way. The walls, or the protoplast, or both, are very resistant to germination. They evidently germinate in buried habitats without light. They partially or wholly lack chlorophyll. Symbiotic relationships are established with suitable fungi. Only recently have we gained an insight into the nature of these spores through the laboratory studies of Dean P. Whittier (1972, 1973), who has succeeded in germinating different genera of pteridophytes with subterranean, mycorrhizal gametophytes.

In the course of ecological studies of pteridophytes by Hill in connection with his doctoral dissertation, and in the course of general studies by Wagner over 20 years in the Great Lakes area, we endeavored to estimate the earliest time of release of spores, using field observations in various parts of Michigan. Time of spore discharge is estimated by (a) the maturity of the spores and (b) actual observations of the falling spores by shaking the plant or by finding accumulations around the plant. There is, naturally, variation from south to north, and pteridophytes in the Upper Peninsula may release their spores as much as two weeks later than those near the Ohio or Indiana border. There is probably also year-to-year variation correlated with average rainfall, number of overcast days, and temperature. Although we have no precise data on this, our impression is that, on the average, most of the spore discharge occurs during approximately two weeks.

In tabulating all of the native homosporous pteridophytes known from Michigan, it soon became evident that the discharge times showed definite taxonomic correlations. We distinguished three seasonal classes--early, middle, and late, the first prior to June 1, the last after August 15. By far the majority of spores--57 out of a total of 85 homosporous taxa--are released between June 1 and August 15. All of these except seven (*Botrychium lunaria, B. minganense, B. simplex, B. matricariifolium, B. lanceolatum,* and the two *Ophioglossum* taxa) are what we term above "typical spores," lacking chlorophyll and germinating readily on mineral media, so far as we know.

Our interest is focused upon the Early spores and Late spores, because it seems more than a coincidence that these are the ones which deviate functionally from the typical spores. The early spores are all of the green type, thin-walled, short-lived, and quickly germinable (Table 1). Included here are the species of horsetails and scouring rushes, the osmundas, and the onocleoid ferns (*Matteuccia* and *Onoclea*). It is especially interesting that at least some of the species have become adapted to retaining their spores from the time of production throughout the winter, releasing them only after the first couple of weeks of spring. This includes, for example, *Equisetum hyemale,* as well as the onocleoid ferns. The strobili or pinnules remain solidly closed throughout the cold months, and then spread apart in early spring. We have actually found spore discharge from *Onoclea* scattered across the snow in late March, 1973 (Waterloo Recreation Area, Washtenaw County) in what may

TABLE 1. A Structural and Functional Comparison of Early and Late Spores.

EARLY SPORES	LATE SPORES
Thin-walled	Thick-walled
Chloroplasts	No chloroplasts
Little storage material	Much storage material
Non-resistant	Resistant
Short-lived	Long-lived
Growth on mineral media	Growth requiring fungi or organic nutrients
Overwintering, if at all, in protective strobili or pinnules	Overwintering as free spores
Discharge mostly before June 1	Discharge mostly after August 15
Season wet and rainy	Season mostly dry
Germination at surface	Germination mainly below surface
Germinating quickly	Germinating slowly
Germling wholly photosynthetic	Germling only partially or not at all photosynthetic

have been the result of misleading climatological clues (probably a common phenomenon in the Ann Arbor area!). Other early spore release is accomplished by the rapid formation of ephemeral strobiliferous shoots, as in *Equisetum arvense* and *E. pratense.*

Four out of 12 Ophioglossaceae and all of the 11 Lycopodiaceae discharge their spores late. Thus approximately two-thirds of the pteridophytes with mycorrhizal gametophytes, most of which are subterranean, scatter their spores mainly after August 15. These spores are thick-walled, long-lived, and without chlorophyll, but they have an abundance of storage materials (Gullvag, 1969).

What is the ecological significance of these correlations? Green spores are produced in the early part of the growing season, usually long before the typical "summer" spores, and the difficult-to-germinate spores are generally produced at the end of the growing season. The early part of the growing season is characterized by raininess and greater moisture, for the most part, than later. Lloyd and Klekowski (1970) have discussed green-spored pteridophytes, and they conclude that lack of selective pressure for dormancy has maintained the condition.[1] However, in consideration of the fact that in at least some of the green-spored pteridophytes of the Great Lakes area, the spores do in fact "rest" over winter, contained in cocoon-like strobili or rolled pinnules, we cannot exactly say that they lack dormancy. On the other hand, the spores are protected by thick coverings during the cold months, and so there is no need for thick spore walls. Remaining green during their dormancy

[1]Miss Leslie Towill (pers. comm.) has found that spores of *Onoclea sensibilis* remain viable at a level of approximately 50% after 2½ years storage at 4° C. In their chart of reports of spore germination and viability in ferns, Lloyd and Klekowski (1970) give lengths of viability for species of *Equisetum* ranging from 12 to 24 days; of *Osmunda,* 10 to 210 days; and of *Grammitis,* under 45 days. (In contrast, such genera as *Anemia* (14 years), *Pellaea* (34 years), *Dicksonia* (22 years), and *Asplenium* (48 years), illustrate examples of non-green-spored genera with very long survival.)

enables them to germinate immediately in the spring and to take advantage of the spring moistness, thus getting a head start over typical spores discharged later. It is likely that the thin walls, which allow for more rapid rates of water uptake and gas exchange, and the ability to germinate at low temperatures also contribute to the rapidity of germination in green spores.

In an experiment by the first author (unpublished), green and non-green spores were compared as to temperature requirements for germination. Of the species with green spores (*Osmunda claytoniana, O. cinnamomea, Onoclea sensibilis,* and *Matteuccia struthiopteris*), germination occurred at high percentages at 5° C. Of 13 species with non-green spores, mainly species in the "summer spore" category, only two germinated and these only at very low percentages. At higher temperatures, germination rates increased markedly in nearly all of the species. Rates of prothallial growth at 10° C were also higher in the green spores. Thus it appears that the ability to germinate and grow at relatively low temperatures is another adaptive feature of Early spores.

With respect to the spores of the mycorrhizal taxa, the situation is perhaps the opposite of the green-spored ones. Since the spores of botrychiums and lycopodiums call for percolation into the soil (sometimes germinating as much as 4 cm below the surface) and establishing fungal symbiosis, they are presumably extremely resistant. The thick wall and large amount of storage compounds undoubtedly contribute to the great longevity typical of the Late spores. The drought conditions of late August and September will have little or no effect on them, and they will be unlikely to germinate. Considering the various factors that may be operative, we conclude as follows:

1. Time of spore discharge is probably not as critical in these species as it is in green-spored species.
2. However, releasing spores late may allow for more seasonal input of energy for spore production and a larger "crop" of spores and/or more stored energy per spore.
3. Maximum percolation of spores into the soil can be accomplished when the soil is dry and porous and when rain occurs sporadically.
4. The spores will then already be in position for infection by fungi during the moist period of the following spring.

Some of the points made in our conclusions are subject to testing. It is our hope that by comparing Early with Late spores we may gain an insight into the hitherto quite obscure biological significance of some of the differences observed in the spores of pteridophytes.

ACKNOWLEDGMENTS

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Selling, Olof H. 1946. Studies in Hawaiian pollen statistics. Part I. The spores of the Hawaiian Pteridophytes. B. P. Bishop Museum Spec. Publ. 37: 1-87, pl. 1-7.

Whittier, Dean P. 1972. Gametophytes of Botrychium dissectum in axenic culture. (Abstract). Am. Jour. Bot. 59: 677.

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MICHIGAN PLANTS IN PRINT

New Literature Relating to Michigan Botany

A. MAPS, SOILS, GEOLOGY, CLIMATE, GENERAL

Brander, Robert B., et al. 1973. Research in Primitive Environments. Naturalist 24(1). 32 pp. $1.90. [This is a special number of the journal published by the Natural History Society, 315 Medical Arts Bldg., Minneapolis, Minnesota 55402. Illustrated by handsome color and black-and-white photos and a map, it is devoted to articles on the McCormick Experimental Forest in Marquette and Baraga counties, Michigan, including ones on vegetation, reptiles and amphibians, and "Outdoor Challenge and Mental Health" (by Robert Hanson of Marquette). Members of the Michigan Botanical Club who attended the campout at Marquette last spring may obtain a copy from Carl Tubbs, Northern Hardwoods Laboratory, U.S.D.A., 806 Wright St., Marquette 49855.]

Booth, Walter, Juniata Cupp, & Max Medley. 1973. Grand Mere: A Very Special Place. Grand Mere Association, Box 140, Stevensville 49127. 100 pp. $3.00 (+ $.29 postage). [Includes material on geologic history, amphibians, reptiles, birds, mammals, and habitats, with a list of vascular plants recorded from the Grand Mere area in Berrien County between 1959 and 1973. Several photos, including some in color. An attractive book about a choice natural area.]

Brown, Paul Martin. [1973]. An Introduction to the Limestone Sinkholes of Northeastern Michigan. Jesse Besser Museum [Alpena]. 28 pp. $.75. [Brief discussion of Alpena and Presque Isle county sinkholes, with location maps, geological origin, fossils, and lists of some plants.]

Koenings, Jeffery P., & Frank F. Hooper. 1973. Organic phosphorus compounds of a northern Michigan bog, bog-lake system. Mich. Academ. 5: 295-310. [Chemical studies on North Gate Lake, Gogebic Co.; map shows depth contours and position of mat.]

B. BOOKS, BULLETINS, SEPARATE PUBLICATIONS

Brose, David S. 1970. The Archaeology of Summer Island: Changing Settlement Systems in Northern Lake Michigan. Anthrop. Pap., Mus. Anthrop. Univ. Mich. 41. 238 pp. + 35 pl. $3.00. [Since a page and a half purport to characterize the vegetation of this island in Delta Co., the work must be listed here, but with a caution as to its inaccuracy. The identifications of white oak, common hazelnut, gooseberry (*Ribes oxyacanthoides*), "blackberry" (*Rubus occidentalis,* which is black raspberry), jack pine, black spruce, and sweet-fern are all seriously questioned, on the basis of the editor's four days botanizing on Summer Island and examination of all the specimens collected in 1968 during a survey project of Summer Science Camp. These species would all be interesting additions to the known flora of the island, if indeed they occur there. A few are possible, although not yet a matter of botanical record, but others which do not occur in that part of the state at all are quite unlikely.]

Cleland, Charles Edward. 1966. The Prehistoric Animal Ecology and Ethnozoology of the Upper Great Lakes Region. Anthrop. Pap., Mus. Anthrop. Univ. Mich. 29. 294 pp. $3.00. [Includes introductory material on biotic provinces in the Great Lakes region and on paleoecology, summarizing previous work on pollen analysis, etc., in Michigan.]

Crum, Howard, 1973. Mosses of the Great Lakes Forest. Contr. Univ. Mich. Herbarium 10. 404 pp. $6.00 (+ $.50 postage). [Although oriented especially to the 5 counties around the Straits of Mackinac—for which distributional data are cited—the introductory key includes all Michigan genera and the text gives means of identifying most species of the entire Great Lakes-St. Lawrence area. There are full descriptions, 1004 figures, a complete glossary, and many interesting excursions in the biology and natural history of mosses. A fuller review will appear later.]

Jones, Volney H. 1968. Four textile products from the Burnt Bluff Site (B-95), Michigan. pp. 95-97 in The Prehistory of the Burnt Bluff Area, assembled by James E. Fitting. Anthrop. Pap., Mus. Anthrop. Univ. Mich. 34. $3.00. [One fragment is a braided fabric composed of strips of bark from white-cedar, *Thuja occidentalis.*]

Ola'h, György Miklós. 1969. Le Genre Panaeolus Essai Taxinomique et Physiologique. Revue Mycol. (Paris) Mem. 10. 273 pp. + 20 cartes perforées. [One of the 20 species is cited from Burt Lake, Cheboygan Co. Monograph includes keys, descriptions, illustrations, a McBee punch card for each species, and nomenclatural misunderstandings. Four species are cited as "nov. sp." when in fact they were described the previous year (Revue Mycol. 33), and an unnecessary new combination is made on the anachronistic grounds that since the Code has required a Latin diagnosis since 1935, a 1923 name without Latin is invalid.]

Raven, Peter H., & David P. Gregory. 1972. A Revision of the Genus Gaura (Onagraceae). Mem. Torrey Bot. Club 23(1). 96 pp. $7.50. [*G. longiflora* is cited from Jackson and Monroe counties and mapped in the former; *G. biennis* is cited from 6 counties (one collection each) and mapped at 7 localities but since maps lack county borders exact correlation is difficult. A full monograph with keys, distribution maps, photographs, and citation of specimens.]

Shetron, Stephen G. 1973. Relationship of Wood Quality to Soil, Age and Density Class in Sugar Maple. Mich. Tech. Univ., Ford For. Center Res. Note 10. 10 pp. [Study based on single-tree samples from old-growth northern hardwood stands on 11 soil series in four western Upper Peninsula counties (no further locality data).]

Smith, Helen V., & Alexander H. Smith. 1973. How to Know the Non-Gilled Fleshy Fungi. Wm. C. Brown, Dubuque. 402 pp. $5.50 (wire binding). [The latest and welcome volume in the familiar Pictured Key Nature Series covers puffballs, morels, boletes, false truffles, stinkhorns, and related fungi. (The gilled mushrooms will be another volume.) As can be expected, Michigan and even specific counties figure prominently in many statements of distribution. Illustrated mostly with charcoal drawings. Includes directions for collecting and studying specimens. The most complete work for these fungi all across the continent.]

C. JOURNAL ARTICLES

Ahmed, S. Iftikhar, & R. F. Cain. 1972. Revision of the genera Sporormia and Sporormiella. Canad. Jour. Bot. 50: 419-477. [*Sporormiella leporina* cited from Lenawee (as "Linawee") Co.]

Brander, Robert B. 1973. Life-history notes on the porcupine in a hardwood-hemlock forest in Upper Michigan. Mich. Academ. 5: 425-433. [Porcupines were seen to feed on five tree species in Iron Co.: hemlock, sugar maple, basswood, elm, and yellow birch.]

Dayanandan, P., & P. B. Kaufman. 1973. Stomata in Equisetum. Canad. Jour. Bot. 51: 1555-1564. [Material of six taxa was from various Michigan localities and two others were from pot cultures at the University of Michigan Matthaei Botanical Gardens.]

Demoulin, Vincent. 1972. Espèces nouvelles ou méconnues du genre Lycoperdon (Gastéromycètes). Lejeunia 62: 1-28. [Many paratypes of *L. americanum* cited from Michigan localities, and one of *L. lambinonii; L. calvescens* also cited from Michigan.]

Duncan, Thomas. 1973. Three plant species new to Canada on Pelee Island: Triosteum angustifolium L., Valerianella umbilicata (Sull.) Wood, and Valerianella intermedia Dyal. Canad. Field-Nat. 87: 261-265. [Map of North American distribution of *V. intermedia* shows two Michigan locations.]

Henry, Robert, Bruce Brooks, & Craig Davis. 1973. Population density of Larix laricina in a sphagnum bog mat habitat. Mich. Academ. 5: 529-535. [Study at Vestaburg Bog, Montcalm Co.]

Homola, Richard L. 1972. Section Celluloderma of the genus Pluteus in North America. Mycologia 64: 1211-1247. [Most of the species for which any distributional data are given are cited from Michigan, with no further locality except for the type of *P. pallidus* from Tahquamenon Falls State Park.]

Kaufman, Peter B., et al. 1973. Silicification of developing internodes in the perennial scouring rush (Equisetum hyemale var. affine). Develop. Biol. 31: 124-135. [Study of shoots from a greenhouse culture established from plants from the vicinity of the University of Michigan Biological Station at Douglas Lake.]

Kivilaan, A., & Robert S. Bandurski. 1973. The ninety-year period for Dr. Beal's seed viability experiment. Am. Jour. Bot. 60: 140-145. [After 90 years, 20% of the seeds of *Verbascum blattaria* germinated; none of the other original 20 species appeared viable in this famous long-term project on seed vitality at Michigan State University.]

Kondo, Katsuhiko. 1972. A comparison of variability in Utricularia cornuta and Utricularia juncea. Am. Jour. Bot. 59: 23-37. [Distribution map shows several localities for *U. cornuta* in Michigan.]

Lowden, Richard M. 1973. Revision of the genus Pontederia L. Rhodora 75: 426-487. [Map includes Michigan localities for *P. cordata* var. *cordata* and one representative specimen (from Barry Co.) is cited; one Michigan record for var. *lancifolia* is mapped and cited (Schoolcraft Co.).]

Pfister, Donald H. 1973. The psilopezoid fungi. III. The genus Psilopezia (Pezizales). Am. Jour. Bot. 60: 355-365. [*P. deligata* and *P. nummularia* are cited with full data from several Michigan localities.]

Pringle, James S. 1973. The cultivated taxa of Clematis, Sect. Atragene (Ranunculaceae). Baileya 19: 49-89. [Generalized distribution map shows *C. occidentalis* var. *dissecta* (*C. verticillaris*) in most of Upper Peninsula.]

Pullum, Peggy Anne, & Frederic H. Erbisch. 1972. Effects of gamma radiation on the lichen Cladonia verticillata (Hoffm.) Schaer. Bryologist 75: 48-53. [Materials were from Keweenaw and Houghton counties.]

Smith, S. Galen. 1969. Natural hybridization in the Scirpus lacustris complex in north central United States. Current Topics in Plant Science pp. 175-200. Includes considerable data on *S. acutus, S. validus,* and hybrids. Many of the field studies were made in vicinity of University of Michigan Biological Station in 1966, as well as near Escanaba and Traverse City. Mackinaw City dock area, Duncan Bay, and Indian River are erroneously said to be in Emmet Co. rather than Cheboygan; U.S., not "Wisconsin," highway 23 ends at Mackinaw; and the Fish Creek locality cited on p. 196 as in Michigan is actually in Wisconsin.]

Smith, S. G. 1973. Ecology of the Scirpus lacustris complex in North America. Polskie Arch. Hydrobiol. 20: 215-216. [Includes observations on *S. validus* and *S. acutus* near south shore of Straits of Mackinac.]

Wooten, Jean W. 1973. Taxonomy of seven species of Sagittaria from eastern North America. Brittonia 25: 64-74. [Distribution map shows several Michigan localities for *S. graminea* and *S. cristata*, and one for *S. rigida*.]

D. HISTORY, BIOGRAPHY, EXPLORATION

(Anon.) 1973. Beal Centennial 1873-1973. Mich. Agr. Exp. Sta., Mich. Science in Action 23. 23 pp. [A well illustrated booklet issued on the centennial of the establishment by Beal of a botanical garden at Michigan State University. Includes information on Sanford Natural Area, the famous seed vitality studies, the Beal-Darlington Herbarium, and Beal's legacy of research at MSU. Available without charge from MSU Bulletin Office, Box 231, East Lansing 48823.]

Editorial Notes

Members of the Michigan Botanical Club and other local naturalists will find many particularly interesting publications listed in sections A, B, & D of "Michigan Plants in Print" on pp. 44-46 of this issue.

Plan to attend the 1974 campout of the Club at the M.S.U. Biological Station on Gull Lake, Friday evening May 24 through Monday, May 27. Details later.

Authors of recent articles who wish manuscripts or original art work returned should notify the editor immediately or they will be discarded.

The Archaeology of Michigan by James Fitting, reviewed in Mich. Bot. 10: 62 (1971) is now a publisher's remainder and may be found at half price in many bookstores.

Gwen Frostic, honorary member of the Michigan Botanical Club and long-time friend of MBC, received the honorary degree of Doctor of Fine Arts at MSU's fall term Commencement, December 1, 1973.

The October number (Vol. 12, No. 4) was mailed October 18, 1973.

Page 1

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(On the cover: "Mushrooms" of ice on a tree along the Red Cedar River in East Lansing, photographed by Garrett E. Crow.)

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March, 1974

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SCANNING ELECTRON MICROSCOPY IN TAXONOMY OF GYROMITROID FUNGI

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INTRODUCTION

Surface features of ascospore structure are generally regarded as significant in the taxonomy of the operculate discomycetes. In some Helvellaceae, they are used as primary characters, both in species identification and in generic distinction (LeGal, 1964; Dissing, 1966). To our knowledge the only published reports on ultrastructure of ascospores of the Helvellaceae are the brief account by Moberg (1970) on *Gyromitra "caroliniana"* and McKnight's (1973) scanning electron micrograph of a spore of *Gyromitra brunnea* Underw. Inconsistencies in the published descriptions of ascospore surface features in the Helvellaceae suggest that magnification beyond that possible with the light microscope would be valuable in determining species limits (McKnight, 1969; 1971). With its great depth of focus at high magnifications, the scanning electron microscope (SEM) gives an exceptionally clear view of surface details. As mentioned by Locci and Quaroni (1970) in their extensive study of *Aspergillus* spores, for definitive taxonomic use numerous observations of this kind should be made on each species to obtain a concept of the range of variation within the species. We are limited from this ideal by the available study material, time, and finances. However, the results reported here can be useful if interpreted cautiously in conjunction with other characters.

MATERIALS AND METHODS

Mature ascospores being discharged from the fungus were collected directly on a 12 mm glass cover slip laid on the hymenium when satisfactory fresh specimens were available. Other samples studied were obtained from herbarium specimens. For these, spores accumulated on the surface of the hymenium or from spore prints were scraped into a drop of water on a cover slip on two-sided transparent tape. After being coated with gold-palladium (ca. 250 Å), the spores were examined and photographed either with a Cambridge "Stereoscan" or with a Hitachi "Hiscan".[1]

Since ascospores are known to mature slowly in the Helvellaceae we deemed it important to use only spores that had been discharged from the ascus in order to give us some sort of standard of maturity. This necessitated the use of dried spores. Many spores, indeed the majority in some mounts,

[1]Mention of a trademark name or a proprietary product does not constitute a guarantee or warranty of the product by the U.S.D.A., and does not imply its approval to the exclusion of other products that may also be available.

were collapsed. Because of this, and for technical reasons, a random selection of spores for photography was not feasible. Abnormalities, which appear in very small numbers in all large spore populations, were avoided. Spores were selected to be typical of the majority in the mount and to show the characteristic features especially well.

Locations of collections studied are indicated by the appropriate herbarium abbreviations from Index Herbariorum. Fifteen species were examined: *Discina apiculatula* McKn. (McKnight 11813, BPI); *Discina larryi* McKn.[2] (McKnight 11777, BPI); *Discina leucoxantha* Bres. var. *fulvescens* Rea (McKnight 11736, BPI); *Discina macrospora* Bubák (Bubák 23.IV.1905, LECTOTYPE, BPI; A. H. Smith 72911, MICH); *Discina parma* Maas G. (HOLOTYPE, L); *Discina perlata* (Fr.) Fr. (Batra 631, BPI); *Gyromitra brunnea* Underw. (Korf 1486, CUP; Pennoyer 3476, BPI); *Gyromitra californica* (Phill.) Raitv. (McKnight F7379, BRY); *Gyromitra caroliniana* (Bosc ex Fr.) Fr. (McKnight 11216, BPI); *Gyromitra fastigiata* (Krombh.) Rehm (McKnight 12880, BPI); *Gyromitra gigas* (Krombh.) Quél. (McKnight 10352, BPI); *Gyromitra infula* (Schaeff. ex Fr.) Quél. (McKnight F7608, BRY; 12623, 13060C, BPI); *Gyromitra sphaerospora* Peck (Korf 1486, CUP); *Gyromitra* sp. (K. Engelmann 22.IV.1965, Xylander 19.IV.1971, L; Wandl, W); *Underwoodia columnaris* Peck (McKnight F616, BRY).

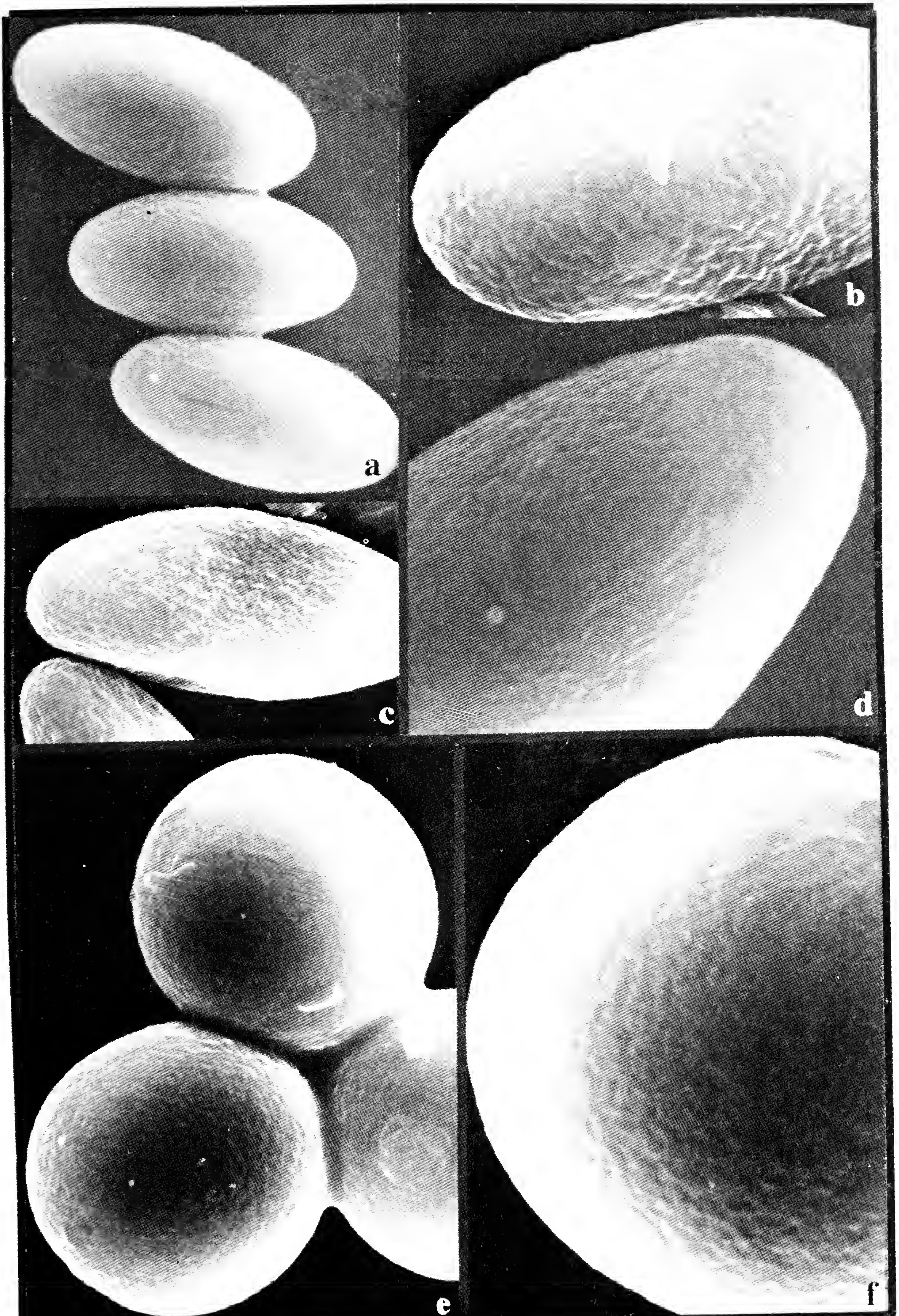
OBSERVATIONS AND DISCUSSION

For convenience, spores of the species studied may be classified arbitrarily into four artificial groups on the basis of surface features seen under the scanning electron microscope: Group I, perispore (Ainsworth, 1971) faintly roughened, appearing smooth at low magnifications (*Gyromitra californica, G. infula,* and *G. sphaerospora,* Fig. 1). Group II, perispore rugose to verrucose or having an incomplete reticulum; secondary roughened surface as in Group I, both between and upon the verrucae (*Discina apiculatula, D. larryi, D. macrospora, D. perlata,* and *Gyromitra gigas,* Figs. 2-4). Group III, perispore with complete reticulum and sometimes with large spicules or platelets on and between the ridges of the reticulum; secondary roughened surface, as in Group I, between and upon the reticulum and spicules (*Discina leucoxantha, D. parma, Gyromitra brunnea, G. caroliniana, G. fastigiata,* Figs. 5-7, 8b-8e). Group IV spores have very coarse, rounded warts and sparse, widely scattered pits in the perispore (*Underwoodia columnaris,* Fig. 8a).

[2]*Discina larryi* McKnight sp. nov. Apothecia sessilia vel substipitata, 2.0-3.5 cm diam., cupulata sed non profunda; hymenium e medio-brunneo griseo-flavum; excipulum ad basim flavido-griseum, prope marginem brunnescens; ascosporae ellipticae, utrinque apiculo brevi truncato ornatae, indistincte verruculosae, 22.0-26.5 × 12.0-13.5 μ. Hab. in solo solitaria, Uinta Mts., Utah. Holotypus KHM 11777, 29.V.1970 (BPI).

⟶

Fig. 1. Scanning electron micrographs of ascospores of *Gyromitra infula, Gyromitra californica,* and *Gyromitra sphaerospora.* a, d, *G. infula,* a, ca. 2,200×, d, ca. 8,800×; b, *G. californica,* ca. 6,800×; c, *G. infula,* ca. 3,500×; e, f, *G. sphaerospora,* e, ca. 4,700×, f, ca. 9,500×.


a
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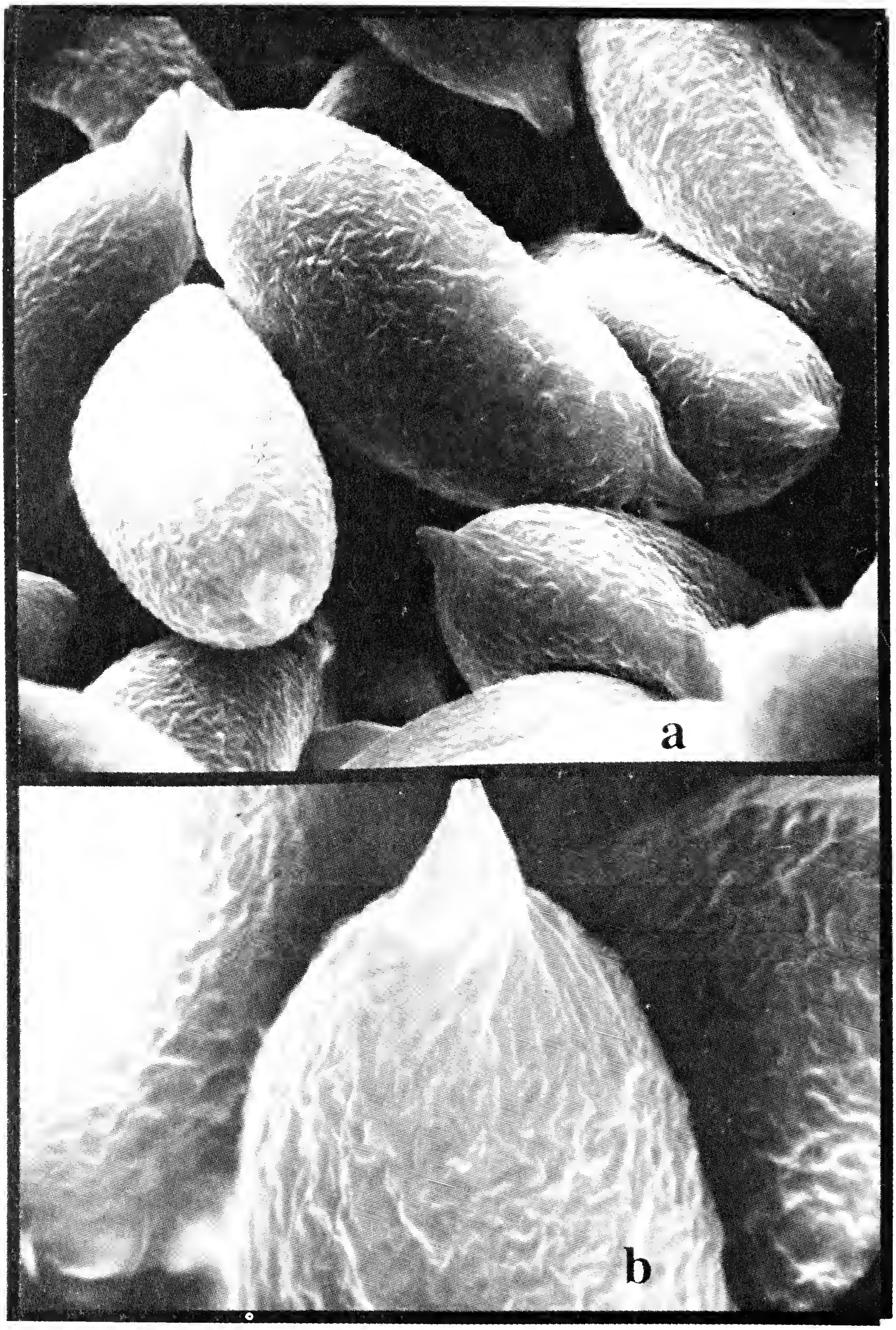


Fig. 2. Scanning electron micrographs of ascospores of *Discina perlata*. a, ca. 2,600×, b, ca. 6,500×.

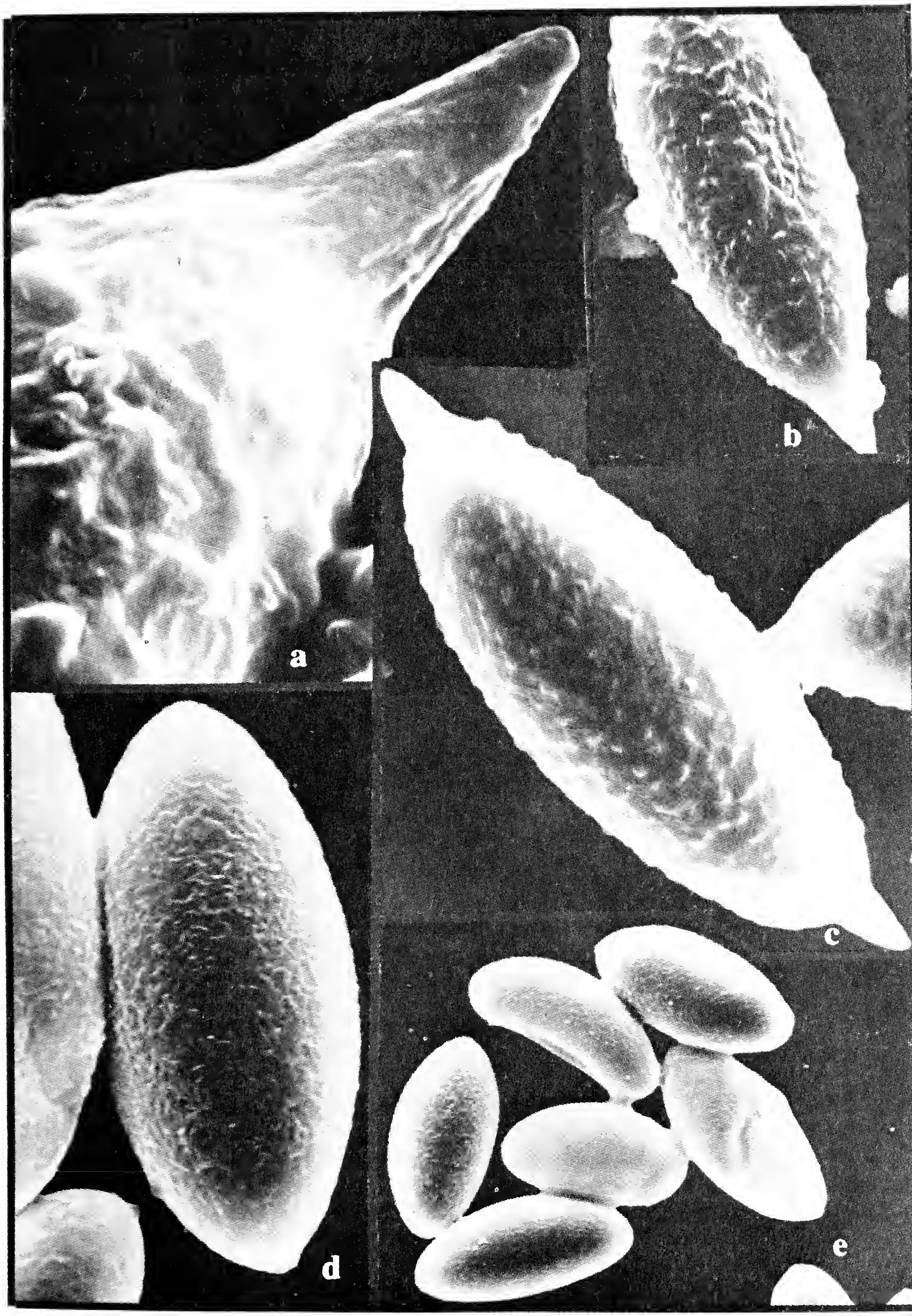


Fig. 3. Scanning electron micrographs of ascospores of *Discina macrospora* and *Discina apiculatula*. a, b, c, *Discina macrospora*, a, ca. 10,000X, b, ca. 2,000X, c, ca. 2,600X; d, e, *Discina apiculatula*, d, ca. 2,900X, e, ca. 1,000X.

Species of Group I. Spores of *Gyromitra californica* (Fig. 1b), *G. infula* (Fig. 1a, c, & d) and *G. sphaerospora* (Fig. 1e & 1f), which appear smooth under the light microscope, show rather distinctive, faintly roughened or rugulose surfaces under SEM. The low, rounded bumps and shallow depressions form an irregular pattern reminiscent of that on the surface of an orange peel. This resembles somewhat the surface of spores of *Aspergillus repens* DeBary (Locci & Quaroni, 1970) and is like the pattern shown by Jones (1968) between the warts on spores of *Ustilago avenae* (Pers.) Rostrup. The depth and spacing of depressions on these surfaces vary in the three species and in the three collections of *G. infula* studied. *Gyromitra infula* from northern Idaho (Fig. 1c) has a much better developed and more distinctly rugulose pattern than that of the Yellowstone and Utah collections (Figs, 1a and 1d). It is like that on *G. californica* (Fig. 1b) and intergrades with the rugose to verrucose pattern on spores of Group II.

Species of Group II. The rugose to verrucose pattern shows up distinctly under SEM on spores of *Discina apiculatula, D. larryi, D. macrospora, D. perlata,* and *Gyromitra gigas*. It is similar to that shown by Grand and Moore (1970) on basidiospores of *Phylloporus rhodoxanthus* (Schw.) Bres. ssp. *americanus* Sing. The epispore is noticeably twisted to form the acute apiculus in *D. perlata* (Fig. 2) and *D. macrospora* (Fig. 3a-3c), but more so in *D. perlata*. At very high magnifications a secondary rugulosity can be seen on spores of this group. Differences in shape and size of the apiculus are clearly evident. The wrinkles and warts seem to be higher and spaced more widely in *D. macrospora* than in *D. perlata*, which would account for their being more conspicuous when seen under the light microscope. Spores of *D. apiculatula* (Fig. 3d, 3e) and *G. gigas* (Fig. 4a & 4b) are almost indistinguishable under SEM in the samples studied. When present, the very abbreviated apiculus of *G. gigas* is obviously an extension or enlargement of the perispore. The tendency for the apiculus to be elongated on some spores and the occasional formation of reticulate pattern elements on the spores of *G. gigas* shows similarities with *G. fastigiata* (Fig. 5c & 5d), as would be expected. The very short, depressed-truncate apiculus on *D. larryi* (Fig. 4d & 4c) resembles that of *D. leucoxantha* (Fig. 5a & 5b). However, the rugulose surface pattern of *D. larryi* is strikingly different from the reticulate pattern on spores of *D. leucoxantha*. The difference, so plainly evident under SEM, is not clearly seen with the light microscope.

Species of Group III. The complete reticulum characteristic of all species in this group varies in detail from species to species. The thick, rounded ridges of the reticulum in *Discina leucoxantha* (Fig. 5a) and *Gyromitra fastigiata* (Fig. 5c) are closer, forming a finer mesh than in *G. brunnea* (Fig. 6a-6c), *G. caroliniana* (Fig. 6d-6g), *Discina parma* (Fig. 8b-8e), and *Gyromitra* sp. from Europe (Fig. 7). Details of the solid, thick apiculus in the former two species, in contrast to the numerous spicules or platelets in the latter four species, are more clearly shown under SEM than with the light microscope. The rounded apiculus of *G. fastigiata* contrasts with the truncate or depressed-truncate apiculus of *D. leucoxantha*. In comparing *G. caroliniana* and *G. brunnea*, the

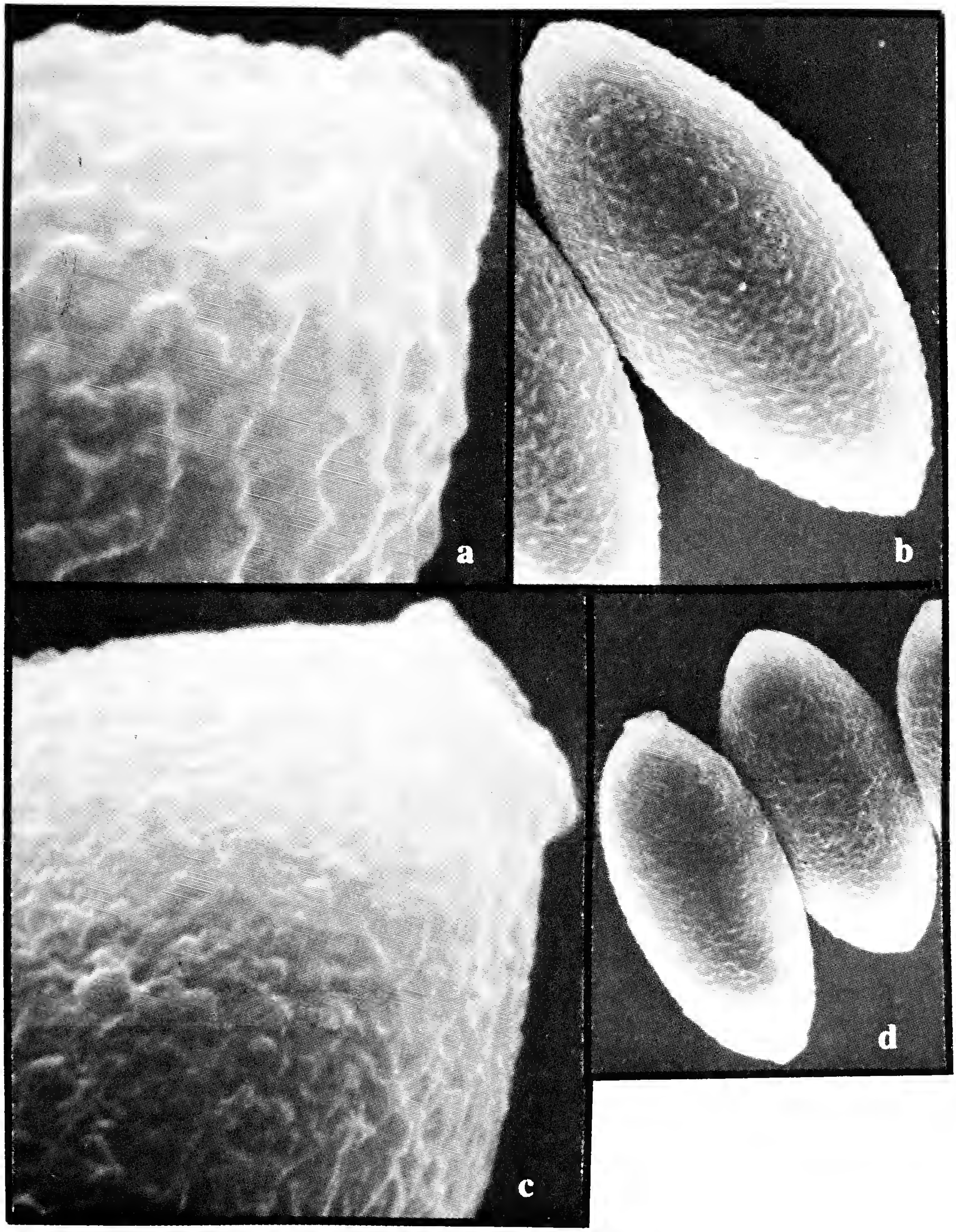


Fig. 4. Scanning electron micrographs of ascospores of *Gyromitra gigas* and *Discina larryi*. a, b, *G. gigas*, a, ca. 10,000X, b, ca. 2,500X; c, d, *D. larryi*, c, ca. 11,000X, d, ca. 2,000X.

subtle and somewhat obscure differences in spore surface pattern reported earlier (McKnight, 1973) are confirmed. The more robust reticulum elements and more numerous elongated appendages apart from the reticulum on *G. caroliniana* (Fig. 6f) are evident. Also, surfaces between the ridges of the reticulum show the minutely rugulose pattern characteristic of Group I spores better than other species of Groups II and III.

Spores of *Gyromitra* sp. (Fig. 7) are of particular interest because of the inconstancy of their surface pattern. This is the species erroneouly called *Gyromitra caroliniana* by several European scientists, and it is the type species of *Fastigiella* Benedix (1969). Svrček and Moravec (1972) and more recently Harmaja (1973) have called it *Gyromitra fastigiata* (Krombh.) Rehm. Figure 7 shows the spores from three dried collections that had thick deposits of fully mature spores on the hymenial surfaces. A collection by Xylander from the vicinity of Sömmerda in central Germany, kindly loaned for this study by R. A. Maas Geesteranus, Rijksherbarium (L) (Figs. 7d, 7f, & 7g), and one by Mrs. Wandl from near Vienna, Austria (Fig. 7c), have some spores that are almost as smooth as the *G. infula* spores of Group I (Figs. 7d & 7g). Others have a rugulose-verrucose pattern somewhat like that of *G. gigas* in Group II, whereas many have a complete reticulum most like that of *G. brunnea* which the fungus most resembles macroscopically. Another characteristic of the species is the development of the reticulum in patches on a single spore. Some parts of it are well developed as in *G. brunnea*, whereas in other places on the same spore the reticulum and spines are very poorly developed (Fig. 7g). It should be emphasized that this variability exists within a single spore mount and that in each case the spores studied were scraped from a thick deposit on the surface of the hymenium, so maturity of spores is not a factor. Another specimen with mostly immature spores was collected by K. Engelmann from the same general area as the Xylander collection (Bad Frankenhausen, on Kyffhauser) and was referred to this species (Maas Geesteranus, 1965). Although otherwise similar to the Xylander and Wandl collections, this one has spores with rounded, knob-like apical appendages (Figs. 7a,b,e). On the basis of what we have seen of their surface structure as revealed by SEM, these spores do not really belong in our artificial Group III. Otherwise, the specimen is microscopically and macroscopically indistinguishable from the Xylander and Wandl collections. Also because of the exceptional variability in the spores of the latter-named collections, and because spores of the Engelmann collection may not be fully mature, we report these together. In view of the fact that this is currently the most disputed species in the genus, both on taxonomic and nomenclatural grounds, it is worthy of more intense study to assess properly the meaning of this extreme variability. There is much greater constancy in the spores of *G. brunnea*, which resembles it most both microscopically and macroscopically, and also in *G. caroliniana* and *Discina parma*, both of which have very similar spores but differ more in gross morphology.

Species of Group IV. A distinctive feature of these spores as seen by SEM is the presence of small, round pits in the perispore (Fig. 8a). Of the species

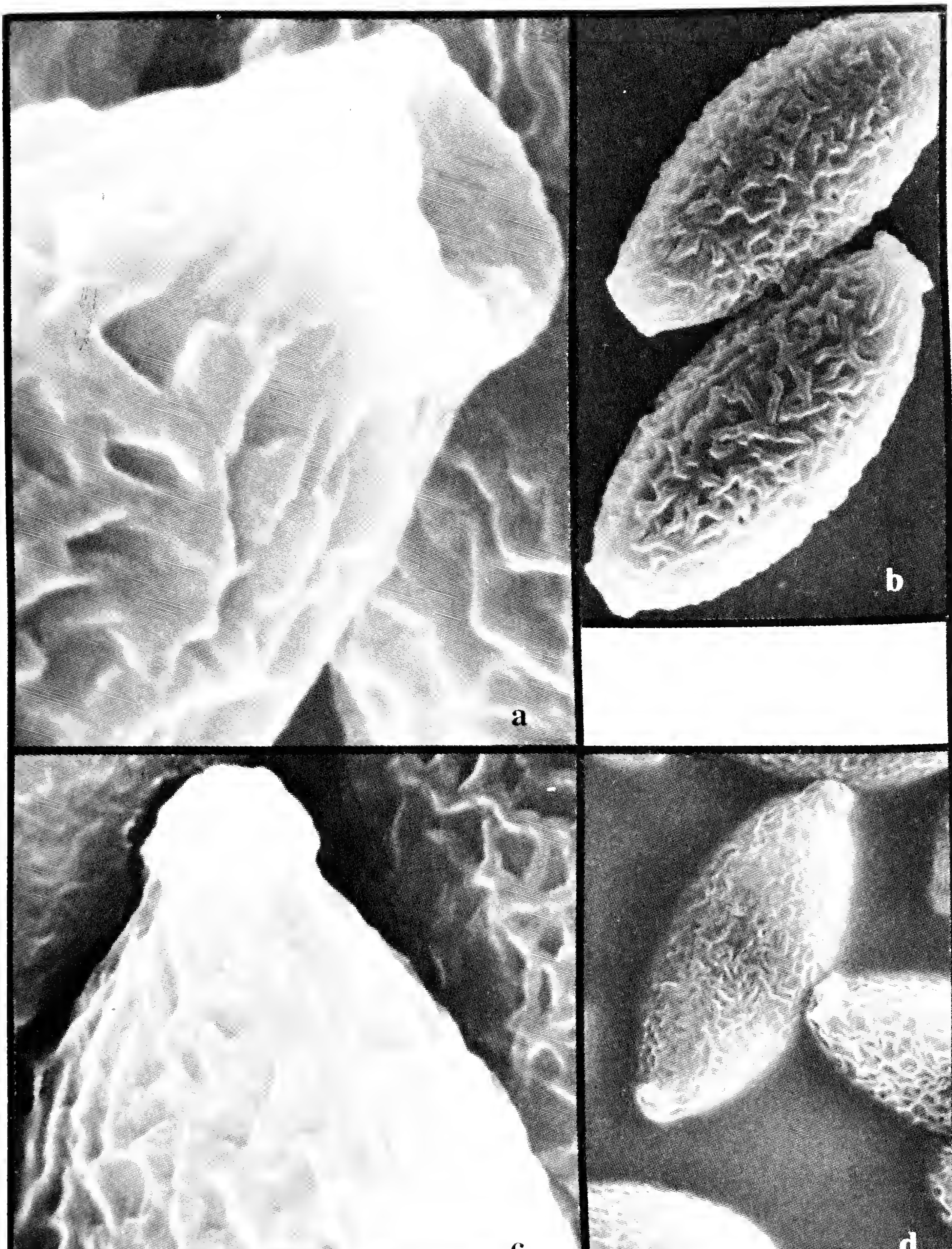


Fig. 5. Scanning electron micrographs of ascospores of *Discina leucoxantha* and *Gyromitra fastigiata*. a, b, *Discina leucoxantha*, a, ca. 11,400×, b, ca. 1,900×; c, d, *G. fastigiata*, c, ca. 10,000×, d, ca. 1,900×.

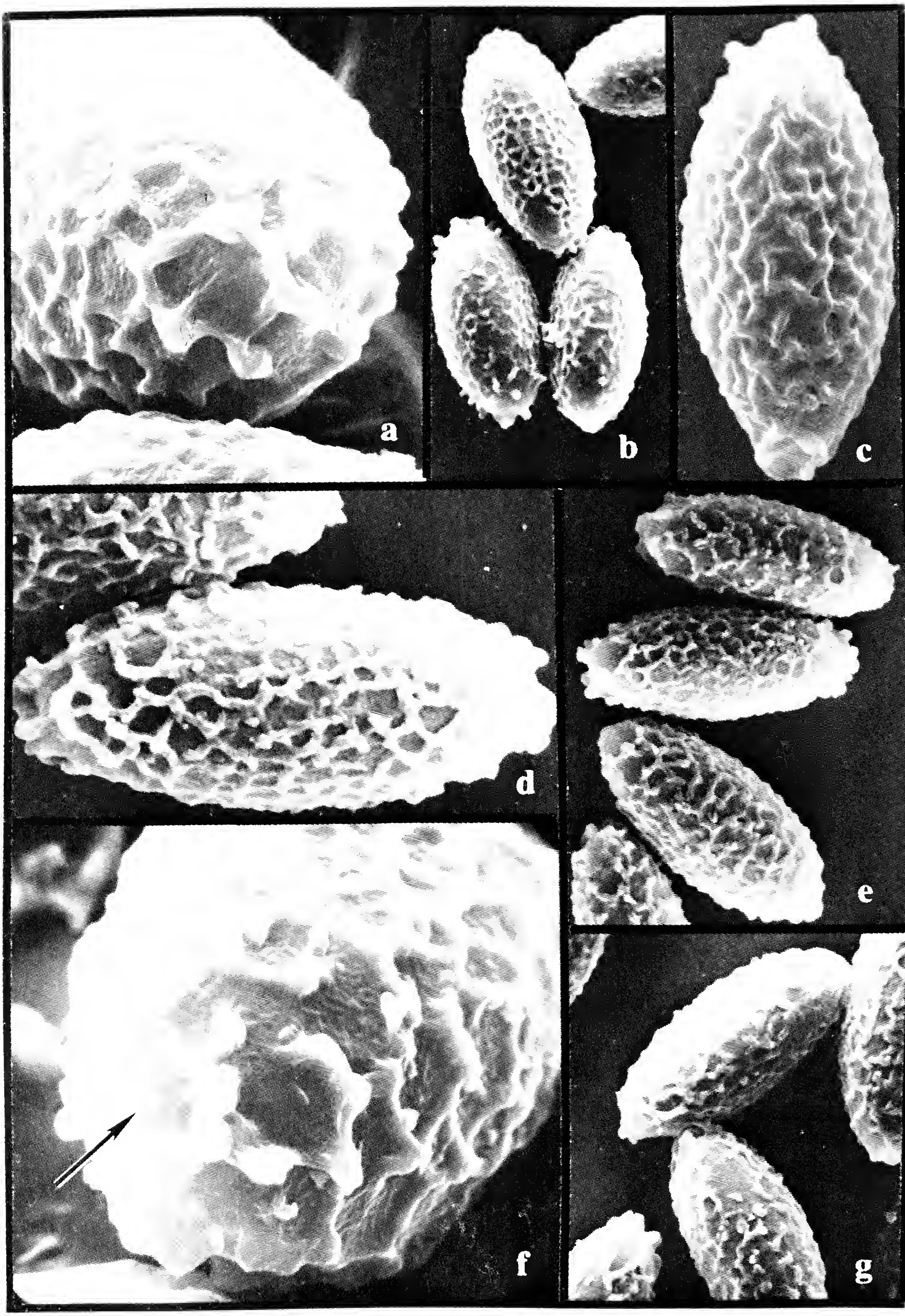


Fig. 6. Scanning electron micrographs of ascospores of *Gyromitra brunnea* and *Gyromitra caroliniana*. a, b, c, *G. brunnea,* a, ca. 6,500×, b, ca. 1,100×, c, ca. 2,100×; d, e, f, g, *G. caroliniana,* d, ca. 2,100×, e, g, ca. 1,100×, f, ca. 6,500×.

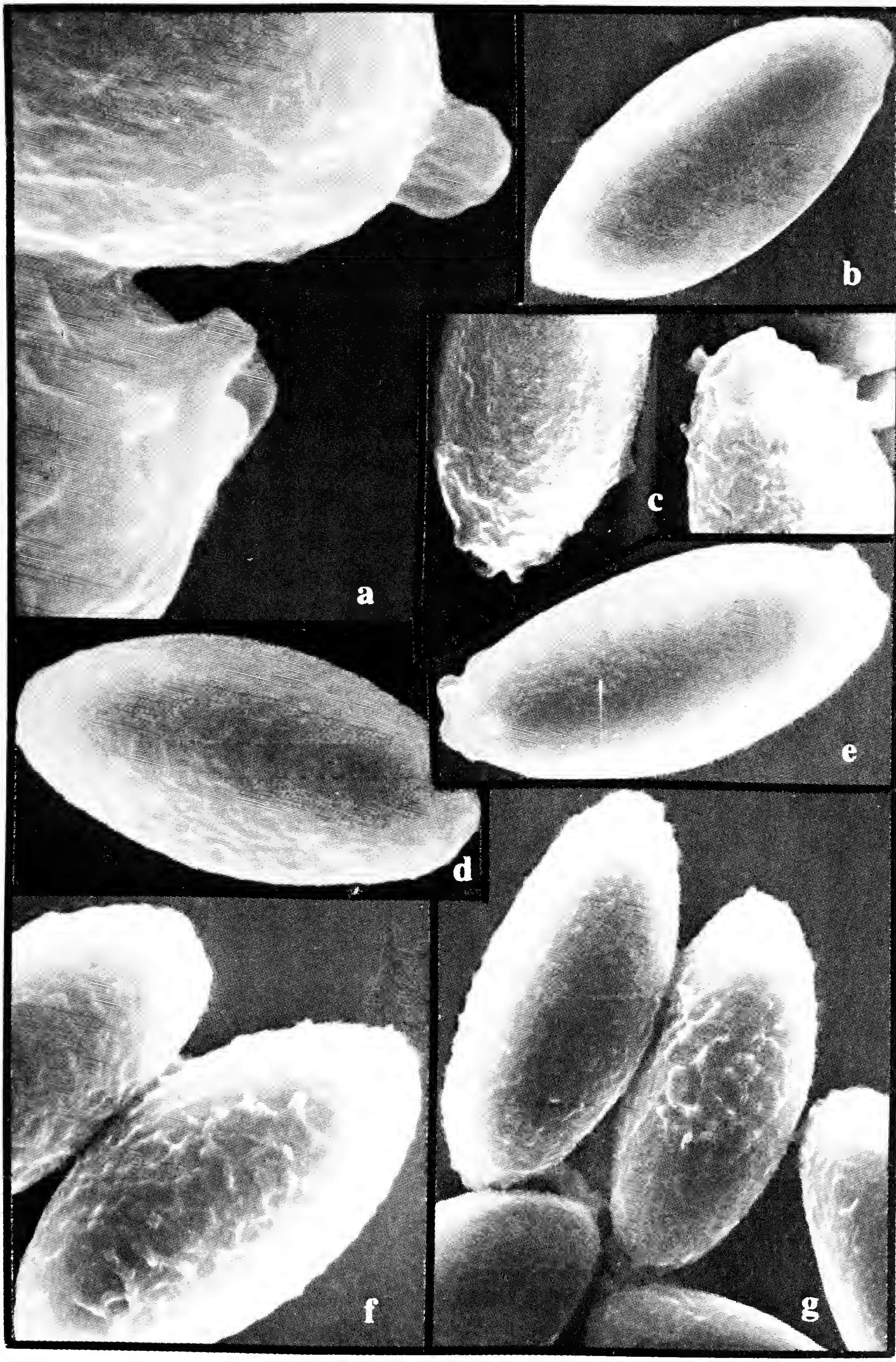
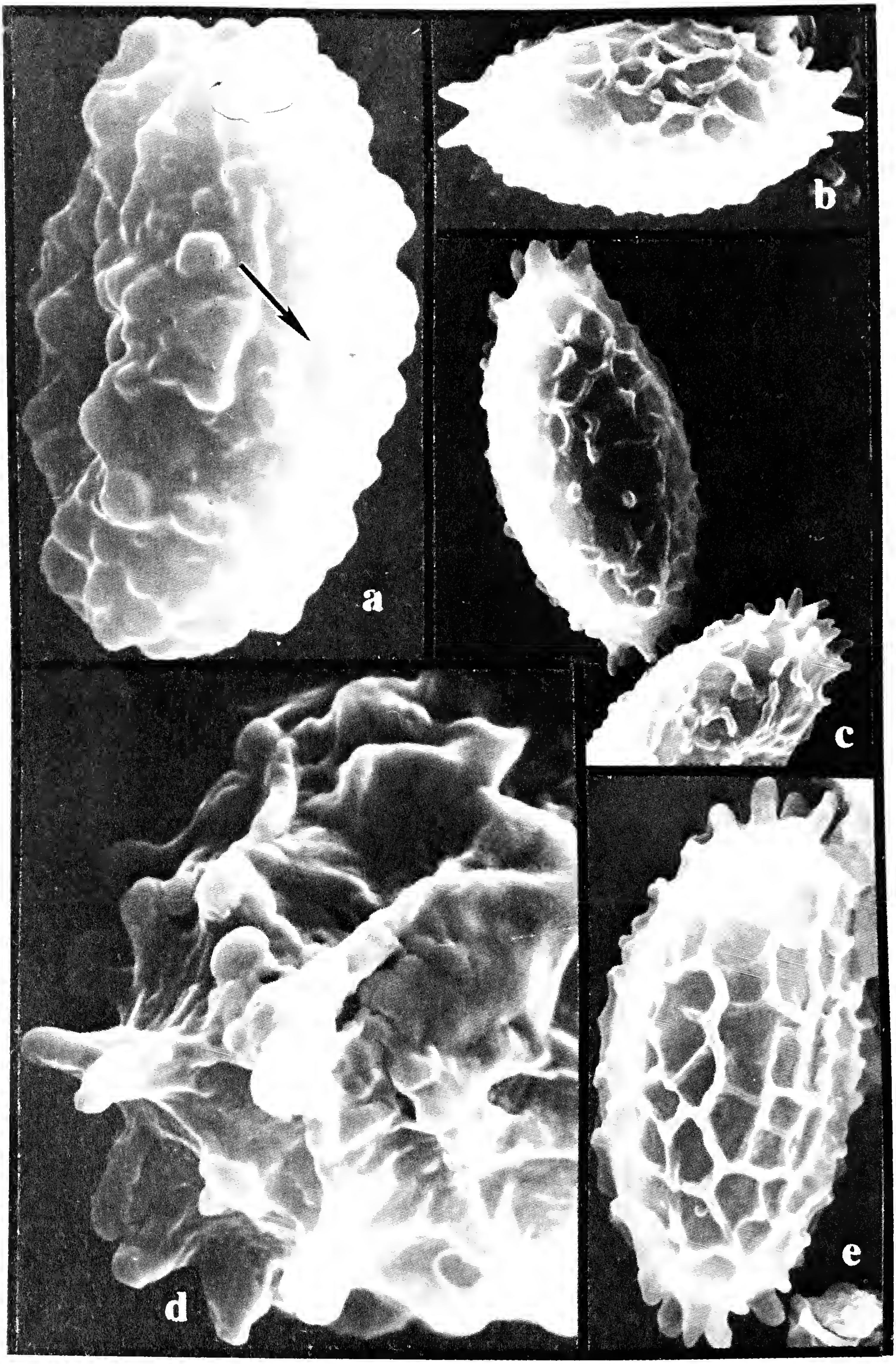


Fig. 7. Scanning electron micrographs of ascospores of *Gyromitra* sp. a, ca. 9,000X, b, e, g, ca. 2,000X, c, ca. 2,900X, d, f, ca. 2,500X.


a
b
c
d
e

examined, only *Underwoodia columnaris* showed this character. Grand and Moore (1971) reported similar pits in spore walls of *Boletellus betula* (Schw.) Gilbert, but spores of this species lack the coarse nodules found on *Underwoodia* spores. Although only one ascocarp was studied, two preparations of its spores were examined at different times, and this feature was found to be consistently present on its spores.

ACKNOWLEDGMENTS

We gratefully express our appreciation to Mr. John Wehrung and Mr. Richard Harniman for technical assistance and advice and to Miss Edith Cash for writing the Latin diagnosis of *Discina larryi*. We are indebted also to the various collectors and herbaria listed whose specimens we were permitted to study.

ADDENDUM

In a paper received here after ours had been submitted for publication, Dissing (1972) published SEM photographs of spores of 11 species of Discomycetes including *Rhizina undulata* Fr. ex Fr. and *Neogyromitra gigas* (Krombh.) Imai (reported here as *Gyromitra fastigiata* (Krombh.) Rehm.) His photographs of the latter species conform well with what we have seen on the same species. In contrast with what Dissing reports for spores of *R. undulata* with a similarly shaped apiculus, we found that the ornamentation does cover the apiculus on spores of *Discina macrospora* (Fig. 3a) and *D. perlata* (Fig. 2).

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Fig. 8. Scanning electron micrographs of ascospores of *Underwoodia columnaris* and *Discina parma*. a, *U. columnaris*, ca. 4,800X; b, c, d, e, *D. parma*, b, c, ca. 1,800X, d, ca. 8,400X, e, ca. 2,700X.

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DICRANUM MUEHLENBECKII, A MOSS NEWLY DISCOVERED IN MICHIGAN

Howard Crum

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Dr. John J. Rochow of the Consumers Power Company recently gave me a few mosses which he collected in connection with ecological studies in the vicinity of the Palisades Nuclear Plant five miles south of South Haven, Van Buren County. Among them was a species of unusual interest not previously known from Michigan, *Dicranum muehlenbeckii* BSG, which occupies a broad range in northern and western parts of North America and also has an arctic-alpine distribution in Europe and Asia. It is distinctly rare in eastern North America: I have seen only a scattering of collections in a range from Quebec to New Jersey and westward to Manitoba and North Dakota. In Michigan it was found with *Thuidium recognitum* (Hedw.) Lindb. on the sandy soil of dunes covered with a mixed forest of oak, ash, and sassafras, with some white pine (no. 673P8, June 1973, in herb. MICH).

Dicranum muehlenbeckii, when well developed (as this material is), resembles *D. fuscescens* Turn. because of leaves strongly crisped and contorted when dry. But the leaves are inrolled at the margins and tube-like when dry, rather than keeled along the midrib, and the margins are not thickened. A further feature of *D. muehlenbeckii* of biological interest and taxonomic importance is the dwarfed nature of the male plants which are mere buds perched on a tomentum of rhizoids covering the stems of female plants. In arctic and alpine regions stunted forms simulate *D. elongatum* Schleich. ex Schwaegr. in size and appearance but differ in having leaves spreading and crisped when dry, serrulate above, with cells only moderately thick-walled and distinctly arranged in long rows separated by white lines. Furthermore, the capsules are about twice as long (about 3-4 mm long).

MACROLICHENS OF BEAVER ISLAND, CHARLEVOIX COUNTY, MICHIGAN

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Department of Biology,
Central Michigan University, Mount Pleasant 48858

Beaver Island, largest of the Beaver Island archipelago in northern Lake Michigan, supports a diverse lichen flora associated with several distinct habitats. A description of the Island and its major vegetation types was recently published (Veldman & Wujek, 1971). The major vegetation types are cedar swamps, bogs, hardwoods, pines, abandoned farms, and partially stabilized dunes.

Very few lichen species inhabit the beech-maple forests found on the west side of Beaver Island. The predominant species in that area are *Peltigera canina, P. polydactyla, Cladonia coniocraea,* and *Physcia orbicularis.* In the bog areas *Cetraria halei* grows on the black spruce and tamarack. The open sandy areas and the coniferous forests show the greatest species diversity. The majority of the species of *Cladonia, Cladina,* and *Stereocaulon,* and also *Cetraria islandica* occur in open areas in the transition zone between the beach and the forests and in abandoned farmlands. The foliose lichens, *Parmelia* spp., *Physcia* spp., *Hypogymnia physodes*, and *Platismatia tuckermanii*, and the fruticose lichens, *Usnea* spp., *Ramalina* spp., *Evernia* spp., and *Alectoria nidulifera*, grow in the coniferous forests on the east and south sides of the island. Specific to the cedar swamps are *Lobaria pulmonaria, Cetraria oakesiana,* and *Peltigera polydactyla.*

Collections were made during the seasons of 1970 through 1973, and are considered to represent a fairly complete record of the lichen flora. Sixty-seven species from 20 genera and 12 families were identified.

SYSTEMATIC LIST OF SPECIES

Names are those in Hale and Culberson (1970). Specimens are deposited in the herbarium of Central Michigan University.

Collemataceae

Collema tunaeforme (Ach.) Ach. ex Degel.

Peltigeraceae

Peltigera aphthosa (L.) Willd.
Peltigera canina (L.) Willd.
Peltigera evansiana Gyeln.
Peltigera horizontalis (Huds.) Baumg.
Peltigera polydactyla (Neck.) Hoffm.

Stictaceae

Lobaria pulmonaria (L.) Hoffm.

Stereocaulaceae

Stereocaulon saxatile Magn.
Stereocaulon tomentosum Fr.

Cladoniaceae

Cladina alpestris (L.) Harm.
Cladina mitis (Sandst.) Hale & W. Culb.
Cladina rangiferina (L.) Harm.
Cladonia cariosa (Ach.) Spreng.
Cladonia cenotea (Ach.) Schaer.
Cladonia chlorophaea (Floerke ex Somm.) Spreng.
Cladonia coniocraea (Floerke) Spreng.
Cladonia conista (Ach.) Robb.
Cladonia crispata (Ach.) Flot.
Cladonia cristatella Tuck.
Cladonia deformis (L.) Hoffm.
Cladonia fimbriata (L.) Fr.
Cladonia furcata (Huds.) Schrad.
Cladonia gracilis (L.) Willd.
Cladonia multiformis Merr.
Cladonia nemoxyna (Ach.) Nyl.
Cladonia pityrea (Floerke) Fr.
Cladonia pyxidata (L.) Hoffm.
Cladonia subulata (L.) Wigg.
Cladonia squamosa (Scop.) Hoffm.
Cladonia turgida (Ehrh.) Hoffm.
Cladonia verticillata (Hoffm.) Schaer

Umbilicariaceae

Actinogyra muehlenbergii (Ach.) Schol.

Candelariaceae

Candelaria concolor (Dicks.) B. Stein

Parmeliaceae

Cetraria halei W. Culb. & C. Culb.
Cetraria islandica (L.) Ach.
Cetraria oakesiana Tuck.
Hypogymnia physodes (L.) W. Wats.
Parmelia bolliana (Müll.) Arg.
Parmelia caperata (L.) Ach.
Parmelia cumberlandia (Gyeln.) Hale
Parmelia rudecta Ach.
Parmelia subaurifera Nyl.
Parmelia subrudecta Nyl.
Parmelia sulcata Tayl.
Parmelia taractica Kremp.

Platismatia tuckermanii (Oakes) W. Culb. & C. Culb.
Pseudevernia consocians (Vain.) Hale & W. Culb.

Usneaceae

Alectoria nidulifera Norrl.
Evernia mesomorpha Nyl.
Evernia prunastri (L.) Ach.
Usnea ceratina Ach.
Usnea strigosa (Ach.) A. Eat.
Usnea subfloridana Stirt.

Ramalinaceae

Ramalina farinacea (L.) Ach.
Ramalina fastigiata (Pers.) Ach.
Ramalina intermedia (Del. ex Nyl.) Nyl.

Physciaceae

Anaptychia kaspica Gyeln.
Physcia adscendens (Th. Fr.) Oliv.
Physcia aipolia (Ehrh.) Hampe
Physcia millegrana Degel.
Physcia orbicularis (Neck.) Poetsch
Physcia setosa (Ach.) Nyl.
Physcia stellaris (L.) Nyl.
Physcia tribacoides Nyl.

Teloschistaceae

Xanthoria elegans (Link) Th. Fr.
Xanthoria fallax (Hepp) Arn.
Xanthoria polycarpa (Ehrh.) Oliv.

ACKNOWLEDGMENTS

We are indebted to Dr. John W. Thomson, University of Wisconsin, for his assistance in identifying some of the specimens and to Dr. M. H. Hohn for use of the facilities of the Central Michigan University Biological Station.

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SCLERODERMA MERIDIONALE DEMOULIN ET MALENÇON, THE CORRECT NAME FOR THE LARGE *SCLERODERMA* OF GREAT LAKES SAND DUNES

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In 1951, A. H. Smith in his *Puffballs and their Allies in Michigan* published a photograph of a curious *Scleroderma* occurring frequently on sand dunes in Michigan and having a strongly developed mycelial pseudostipe. In that publication the fungus was provisionally identified as *S. aurantium* Pers. (= *S. citrinum* Pers.). In 1963, convinced that the Michigan collections represented an autonomous species, Professor Smith used for it the name *S. macrorrhizon* Wallroth. This name was adopted by Guzmán in his monograph of the genus (1970) where a rather broad concept of the taxon was used.

During my stays at the Herbarium of the University of Michigan, I saw some of the Michigan collections and was astonished to see they were exactly conspecific with a species, *S. meridionale*, I had described with Dr. Malençon (1971), and which occurs in northern Africa and southern Europe. When we described this new species, we rejected synonymy with *S. vulgare* var. *macrorrhizum* Fr. for morphological and phytogeographical reasons and did not discuss the name *S. macrorrhizon* Wallroth for we considered it a combination at the specific rank of Fries' name. However Guzmán's quotation "Wallrothio (1833) la redescribió como especie independiente, considerando a la variedad de Fries como un sinónimo dudoso, . . ." (1970, p.351) holds true and typification of the Wallroth and Fries taxa should be considered independently.

Another point to clarify was that while we considered that *S. meridionale* was restricted to a Mediterranean type area, Guzmán gave *S. macrorrhizon* as a species from northern Europe. Guzmán was unaware of the material in the Wallroth herbarium at the University of Strasbourg (STR) and so designated a neotype. I have, however, examined what is most certainly the holotype (Figs. 1,2) for the locality is that given in the original diagnosis. The existence of that material, of course, makes Guzmán's neotypification obsolete.

The two type specimens (other specimens very similar are glued on a second sheet but with no locality mentioned) are subglobular, 4 cm in diameter, with thin peridium smooth (except at the summit where it is somewhat rimose), brownish, and darker near the base. White mycelial strands are abundant, but they do not form a compact yellow pseudostipe as in *S. meridionale*; they are of the type frequently found in any species of *Scleroderma* growing in a loose substratum. The gleba is yellowish olive, with numerous remains of clamp-bearing hyphae. The spores in one specimen are

8.5 - 9.7 - 11.4 μ in diameter[1] excluding a reticulate ornamentation of 1.45 μ mean height; and in the other they are 8.2 - 9.75 - 10.8 μ with the ornamentation 0.9 μ high. These are typical of *S. bovista* Fr. as defined by myself (1968) as well as by Guzmán (1970).

So it is clear that *S. meridionale* Demoulin et Malençon is the correct name for our fungus and that *S. macrorrhizon* Wallroth (1833) is a synonym of *S. bovista* Fr. (1829). Two problems, however, remain: what is *S. vulgare* var. *macrorrhizum* and what is the exact distribution of *S. meridionale*? So as to clarify these problems I asked to borrow from the herbarium of the University of Uppsala (UPS) any Friesian material of *S. vulgare* var. *macrorrhizum* as well as any *Scleroderma* collected around Femsjö. Unfortunately Fries did not preserve material of the var. *macrorrhizum*. This was expected, for he seldom kept material except for collections received from a correspondent. The three collections from the vicinity of Femsjö that I received were all either *S. citrinum* Pers. (= *S. aurantium* auct.; = *S. vulgare* Fr.) or *S. bovista* Fr. I thus have no reason to change my opinion that Fries' variety is an ecological form of *S. citrinum.* I also received two of the collections determined by Guzmán as *S. macrorrhizon* (Skåne: Höganäs, s.d:, H. von Post; and Småland: Öjabyn, September 4, 1887, G. K. Hamilton). Both of them are typical *S. bovista* with rather large spores.

I have also examined the third Scandinavian collection cited by Guzmán, which is also the one designated as neotype of *S. macrorrhizon* (22/8/1952,

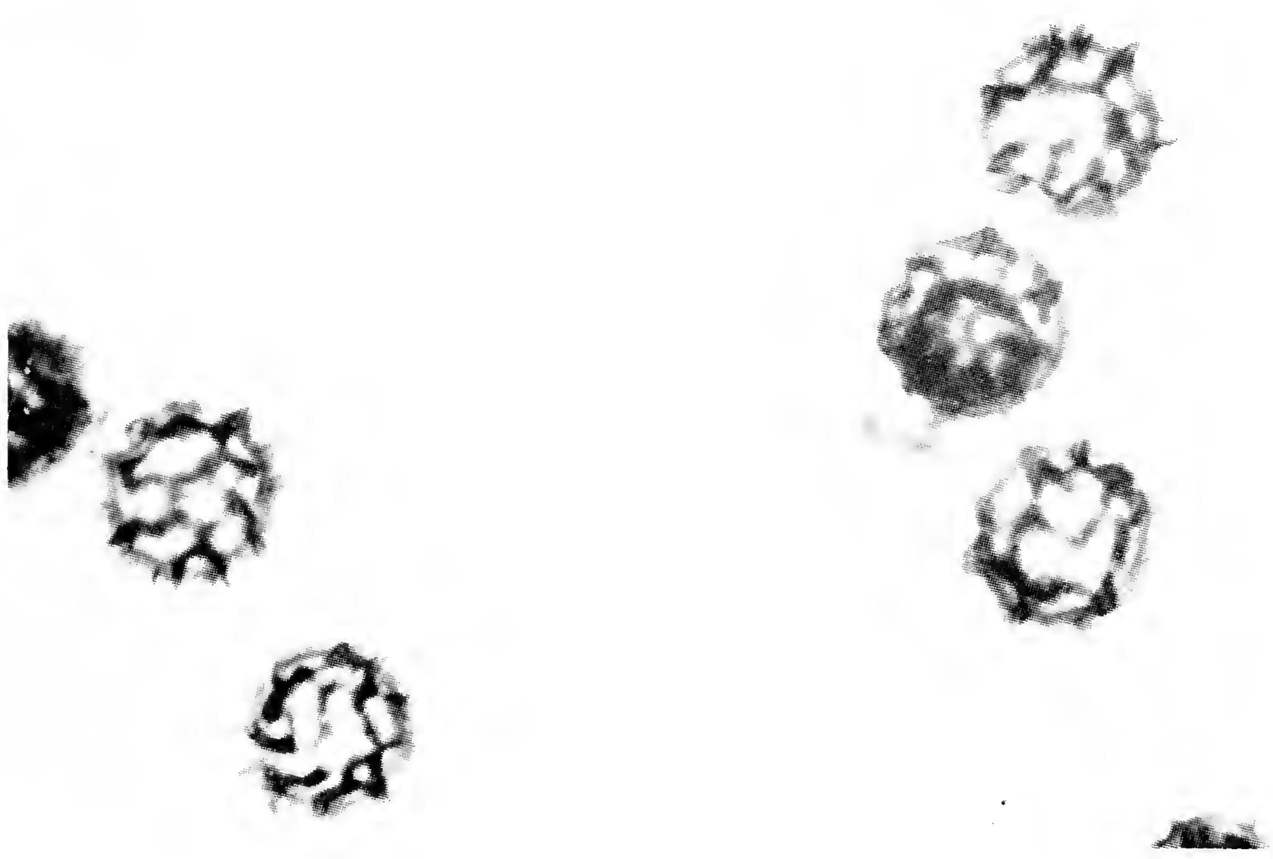

Fig. 1. Spores X1500 of the type of *S. macrorrhizon.*

[1]Middle figure in measurements is mean, others are extremes. I use 30 measurements for each specimen (taken with and without the ornamentation).

Norrbotten, Nedertorneå par., Sandsköret, leg. E. Julin, n° 2258 of Lundell and Nannfeldt, Fungi Suecici Exsiccati, BPI). This specimen is also different from *S. meridionale*. I hesitate, however, to treat it as *S. citrinum* Pers. or *S. bovista* Fr. Many of the features are of *S. citrinum* (e.g. pale yellowish scaly tough peridium) but the peridium is very thin as in *S. bovista*. The spores are intermediate between both these species and are very variable in size (8.5 - 11.2 - 14.0 μ without the ornamentation or 10.6 - 13.5 - 17.2 μ with it) which points toward abnormal maturation. The very northern locality may account for the atypical characters of the fungus (65°34′ N, 23°45′ E is the northernmost locality for a *Scleroderma* in Europe as far as I know).

This explains why Guzmán considered *S. macrorrhizon* a northern species, while I consider it a southern species as expressed in the name *S. meridionale*: Guzmán used as a key character the dimensions of the spores including ornamentation and the presence of pseudostipe. However he did not note the peculiarities in colour and texture of the pseudostipe in *S.*

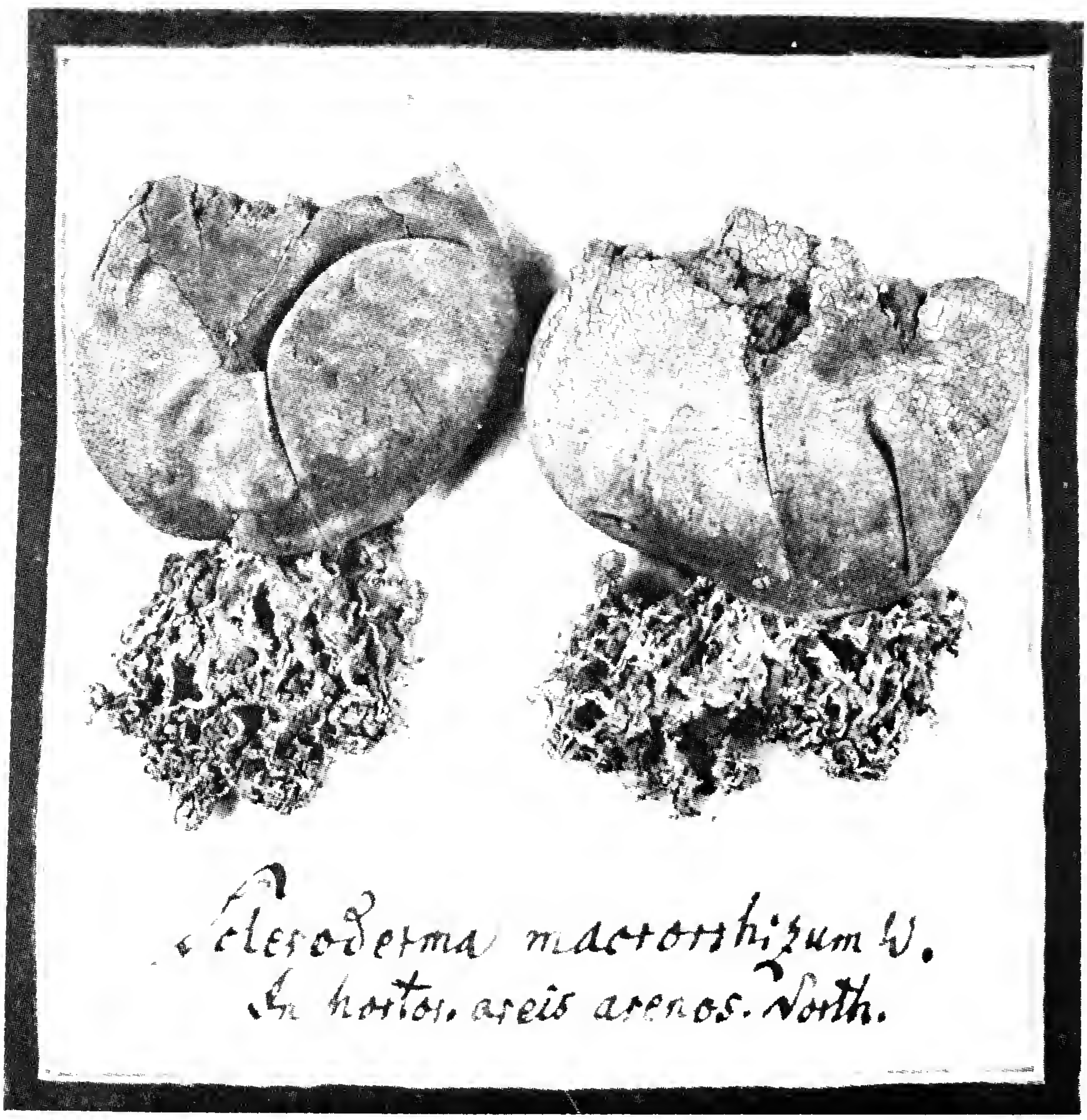

Fig. 2. The type of *Scleroderma macrorrhizon.*

meridionale[2] and considered as *S. macrorrhizon* any specimen of the *citrinum-bovista* group with large spores and somewhat developed mycelial base. The result is that he treated as *S. fuscum* some true *S. meridionale* (Moroccan paratypes, p. 349) which had a reduced pseudostipe, and considered as *S. macrorrhizon* collections that belong either to *S. bovista* or *S. meridionale*, or possibly *S. citrinum*.

Guzmán's misunderstanding of the *S. bovista* group is essentially caused by an overemphasis on spore size, a character which in *Scleroderma* should be used "cum grano salis" (Gross & Schmitt, 1973).

The use of KOH for studying spores of *Scleroderma* and measuring their size (including ornamentation) is confusing and also probably explains why Guzmán recognized both *S. fuscum* and *S. bovista*, a distinction I believe to be unjustified. Boiling in lactophenol is a "must" for the study of *Scleroderma* spores.

The two basidiocarps in the type of *S. macrorrhizon* are a good example of how an erroneous impression is given by spore measurements including the ornamentation. Measured without the ornamentation, the spores are exactly the same size: 8.5 - 9.7 - 11.4 μ and 8.2 - 9.75 - 10.8 μ, but with the ornamentation we have 10.0 - 12.6 - 16.0 μ and 10.0 - 11.5 - 13.5 μ for in one specimen the ornamentation is less developed (with the means 0.9 μ and 1.45 μ respectively). This is a common phenomenon, for the ornamentation in *Scleroderma* spores is rather fragile as well as being subject to developmental conditions. As we stated in the original publication it is true that *S. meridionale* has slightly larger spores than *S. bovista*: 8.7 - 10.3 - 13.1 - 14.4 (-16.6) μ against 8.0 - 9.5 - 10.9 - 12.6 (and not 8.0 - 9.5 - 10.3 - 12.6 as previously printed erroneously). It is not possible, however, to effectively use measurements as a key character for the ranges overlap.

From a phytogeographical standpoint I consider that in Europe *S. bovista* is a widespread species and *S. meridionale* a species restricted to areas with Mediterranean type (live oaks) vegetation. For the U.S.A. I shall not discuss here the problem of *S. bovista* which is more complex, but *S. meridionale* should be looked for in many sandy areas. I have seen it from Michigan and also it was sent to me from the coast of North Carolina by Dr. Kohlmeyer (Morehead City, 8 Janv. 1971, J. Kohlmeyer 2773). It is of course curious that the species is restricted to warm regions in Europe but occurs in America in a relatively cold region such as northern Michigan. This seems to parallel the abundance of *Astraeus hygrometricus* (Smith, 1951 p. 115), a species which in Europe is mainly Mediterranean and frequently associated with *S. meridionale*. It is probable that the warm continental summers of eastern and central U.S.A. are a sufficient condition for the growth of the fungus which would not be limited by winter cold.

[2]Our main diagnostic features of *S. meridionale* are the thick golden yellow, furfuraceous frequently stellately opening peridium and the compact, transversely cracked pseudostipe.

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Review

WILD PLANTS IN FLOWER II: THE BOREAL FOREST AND BORDERS. By Torkel Korling with notes on the species and their distribution by Edward G. Voss. [Published by the author, Box 92,] Dundee, Illinois 60118. 1973. 72 pp. $3.95.

This is Mr. Korling's second in a continuing series of small books dealing with wildflowers of specific regions of North America. He has effectively utilized his more than 50 years of experience in presenting these 32 beautiful one-page photographs (plus the elegant cover).

In selecting some of the most representative boreal forest species, he has made a special effort to include two or more species which appear together, thus reducing the cost per species covered. The composition is carefully executed and the color renditions are far above the average. Unfortunately, dark vertical lines near the left margin on pp. 44, 48, and 59 are distracting. Since a similarly located but lighter colored line (? retouched) appears on p. 2, one is tempted to suggest that if a hair were not in the camera then the fault came with color separations or during printing. The lighting in the photographs on pp. 27, 32, and 60 resembles some I have seen that were made with electronic flash. Such photographs often contain a certain harsh brilliance of color.

The notes on species and their distribution by Dr. Edward G. Voss appear just as expected by those who know him—excellent. The rare teleological phrases, e.g., p. 11 "parachute for dispersal" and p. 57 "stamens open to discharge pollen" can be excused in this sort of non-technical botanical treatment.

For five years I have had on my office wall one of Torkel Korling's fine wildflower photographs. For an even longer time I have been convinced of Dr. Voss's botanical and editorial abilities. This combination of talent has produced a remarkable offering within the means of multitudes.

—James R. Wells

DWARF HACKBERRY (ULMACEAE: *CELTIS TENUIFOLIA*) IN THE GREAT LAKES REGION

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One of the rarest and most often overlooked woody plants in the Great Lakes region is the dwarf hackberry, *Celtis tenuifolia* Nutt. (Fig. 1). Although known from adjacent states, it has never been reported, apparently, from Michigan, where it was discovered for the first time in 1971. This led to a careful exploration for new localities in Michigan, and my students and I became increasingly interested in various questions about it. As a result we not only found numerous additional occurrences of dwarf hackberry, but we also visited all of the areas where this species has been reported in the Great Lakes region.

The "normal" range of dwarf hackberry is well below the line of maximum Wisconsin glaciation. It is a southern species, ranging to Florida. For this reason, the scattered Great Lakes populations have special interest. We tried to determine, therefore, more precisely where the dwarf hackberry occurs in the north, and what the special physical factors are of its habitat and its plant associates. Special efforts were made to record associates as an estimate of the nature of the habitat preferences of the hackberries, and as possible indicators for them. Because of past and present taxonomic interpretations we asked also whether *C. tenuifolia* is truly distinct as a species from *C. occidentalis* L., the common hackberry of the Great Lakes region, with which it has been confused or merged as a variety by some botanists. Further, the question of varieties of *C. tenuifolia* arose in connection with our plants. Finally, we became concerned with the English names of our hackberries because of the widespread variation in usage.

OCCURRENCE AND HABITAT

Figure 4 shows the northern limits of the main range of *C. tenuifolia.* North of this, the plant occurs in very widely spaced and often very local colonies. Jones and Fuller (1955) report it in Illinois as "rare and local," and in Indiana Deam (1921) called it "local." Boivin (1967) refers to the plant in Ontario as growing upon "dunes, particulièrement sur le flanc et le sommet des dunes fixées. Local." Earlier, Fox and Soper (1953), referring also to its occurrence in Ontario, noted that "This shrub or small tree is exceedingly interesting by reason of its great rarity and appearance." Swink (pers. comm.) calls it "one of the Chicago area's rarest woody plants."

I do not question that this species is very rare in the Great Lakes area. However, as a result of the studies to be described below, I suggest that dwarf hackberry is easily overlooked. A hoped-for result of this paper will be to call

Fig. 1. *Celtis tenuifolia.* A typical example from southeastern Michigan (Waterloo Recreation Area). Person is 6 ft. tall. (Photographed by T. L. Mellichamp).

the attention of botanists and naturalists to this plant, and thus reveal additional previously unreported localities.

One of the reasons that dwarf hackberry has been overlooked is no doubt the resemblance it has to various other shrubs and small trees. In our field work, we were frequently confused by superficial similarities of such diverse woody plants as shadbush, *Amelanchier* spp.; mulberry, *Morus alba*; Tatarian honeysuckle, *Lonicera tatarica*; arrow-wood, *Viburnum rafinesquianum*; hazelnut, *Corylus americana*; gray dogwood, *Cornus racemosa*; and especially sun-dwarfed forms of American elm, *Ulmus americana*. It actually turned out that dwarf hackberry is more easily found in winter than in summer. Even though the leaves have fallen, the very noticeably twisted and densely twiggy aspect of the naked stems is highly characteristic. The identification in winter can be quickly checked in two ways—by splitting the twigs longitudinally and observing the chambered pith, and by scratching around underneath the plant for the fallen leaves, which are very distinctive and not easily confused with other, associated leaves. Our most confusing winter look-alikes were compact forms of hawthorns, *Crataegus*, and of mulberries, *Morus*. Occasionally, especially in very dry areas (e.g., dunes), exposed plants of black locust, *Robinia pseudoacacia*, will resemble the dwarf hackberry.

My best advice to persons seeking new localities for dwarf hackberry is simply to look along roadbanks and hedgerows—hardly the place to expect a rare and local species. As it turns out, a very large number of our records are based upon collections along roadbanks and hedgerows, for we found that we could detect plants simply by driving an automobile in appropriate localities and stopping whenever we saw a possible dwarf hackberry plant.

The voucher specimens for the reports given below will be deposited in the University of Michigan Herbarium. Only collections of unusual interest are cited in detail. The collection numbers are those of the author, unless otherwise indicated.

MICHIGAN. The distribution of dwarf hackberry in Michigan is shown in Figure 2. All of our collections so far have come from the rolling to hilly country running northeast to southwest from the vicinity of Brighton, in Livingston Co., to Jackson, in Jackson Co.—a distance of approximately thirty miles. Geologically the country is morainal, and most of the plants occur on the tops and slopes of hills, especially in old fields and apple orchards. Some of the populations are found on steep, more or less wooded slopes above lakes.

The greatest incidence of dwarf hackberry in Michigan is in the Pinckney and Waterloo Recreation areas of Dexter and Lyndon townships of Washtenaw County. In some places, especially west of Silver Lake, southeast of South Lake, and east of Crooked Lake, dwarf hackberry is abundant, in the last-named area being represented by hundreds of plants both of shrub and tree forms. These recreation areas were originally farmlands, but the land, from ancient glacial deposits, was submarginal, and was purchased as part of a resettlement program of the United States Government prior to World War II. The land was later deeded to the State of Michigan, and is currently being used extensively by the public for natural history interpretation, camping, and fishing. Most of the roads are unpaved, and most of the open areas are slowly undergoing succession to dry upland forest dominated by oaks and hickories.

The National Park Service originally planted thousands of trees and vines in certain localities, and we wondered whether or not, in fact, the dwarf hackberry had perhaps been introduced in the area, either deliberately or unintentionally. Part of the rationale for this supposition resulted from the fact that so many of the plants occur in disturbed places: old orchards, fields, roadsides. Also, many of the associates (see below) are naturalized aliens. The notion that dwarf hackberry had been introduced by the National Park Service was dispelled, however, when we began estimating the ages of some of the older trees. We found one old individual with a trunk 16 inches in diameter, from which we obtained a core for counting rings. As it turned out, the middle was occupied with heart rot, so we could obtain a core of only

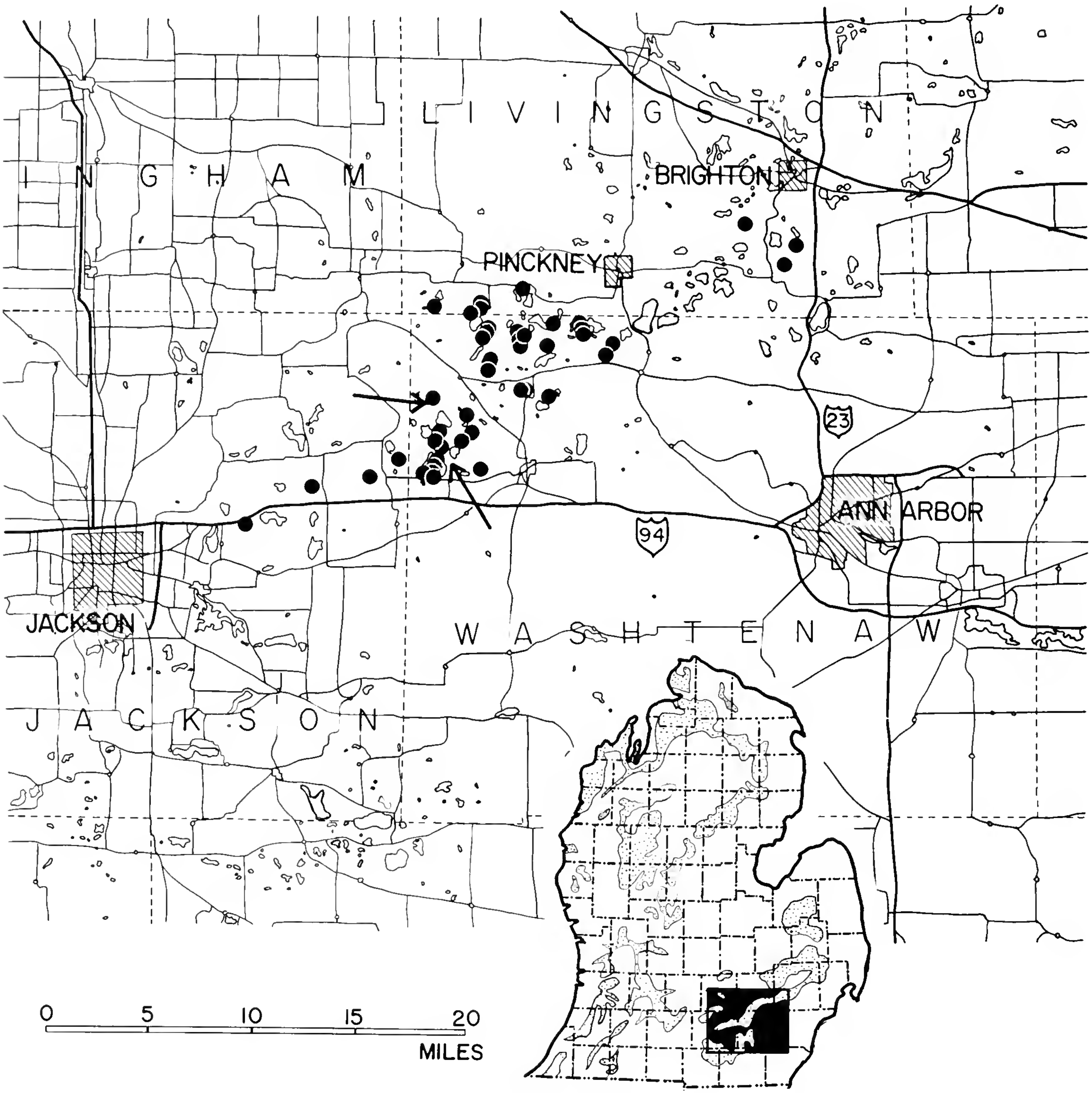

Fig. 2. Distribution of *C. tenuifolia* in southeastern Michigan. Each dot represents a collection. Arrows point to localities where upland localities of *C. occidentalis* have been found. Inset: Map of Lower Peninsula showing area of larger map, and stippled areas of "rolling to hilly relief" (the latter after Veatch, 1953, p. 31).

6 in. of the total 8 in. radius. In the intact part of the core, however, we were able to count 53 rings. We could safely estimate therefore that the tree was at least 60 and perhaps 75 years old, putting its time of origin well before the time of control by the Federal Government. It should be remembered too that plants were being collected in nearby Indiana in habitats similar to these as early as 1920, and in sand dune areas both in Indiana and Ontario at the beginning of the century.

At all of the Michigan sites, the soil is porous and sandy or gravelly. Tests of soil acidity with a Hellige-Truog Soil Reaction Tester gave consistent indications of alkaline reaction, with pH readings of 7.5-8.5. It should be noted that there are many sites, especially in the Pinckney and Waterloo recreation areas, where the pH readings are much lower and well in the acidic range. However, in these places—where various ericads abound, as well as other indicators of acid soils—we found no plants of the dwarf hackberry. In terms of soil reaction, then, the situation in Michigan is not different from that over much of the range of this species, as, for example, in Missouri where we have observed it in limestone regions growing upon rock bluffs, and in rocky woods and open glades.

With the hope of determining a combination of "indicator species" to aid in finding new localities for dwarf hackberry, we went to a number of localities and recorded all of the woody plants growing within 25 feet of a hackberry and all of the herbs within 15 feet. We found a remarkable amount of variation from place to place. The only really consistent associates were species so common that they hardly "define" anything except a disturbed habitat. These included the woody plants *Carya ovalis, Cornus racemosa, Juniperus virginiana, Parthenocissus quinquefolia, Prunus serotina, P. virginiana, Pyrus malus, Quercus rubra, Rubus occidentalis, Sassafras albidum, Toxicodendron radicans,* and *Vitis riparia.* Among the herbs were *Daucus carota, Lactuca canadensis, Melilotus alba, Poa compressa, Solidago canadensis,* and *S. graminifolia.* The associates of *C. tenuifolia* will be discussed further below in connection with other habitats and also in comparison with those in the typical floodplain habitat of *C. occidentalis.*

Perhaps the most remarkable aspect of the occurrence of dwarf hackberry in Michigan is the high number of isolated individuals or groups of only two or three plants. As many as one-half of the dot records on the map in Figure 2 are based upon such finds. Thus one might drive along a road for three or four miles and see only a single individual, this usually along the road bank or a fencerow. Presumably the seeds of this plant are dispersed by birds, and are thus scattered very widely. Only when conditions are ideal do large populations, such as those mentioned above, originate, and very large populations with abundant individuals are decidedly unusual.

Whatever the numbers, colonies of *C. tenuifolia* appear in all cases to be early-successional. Uninterrupted succession would lead to an oak-hickory community and elimination of the dwarf hackberry.

OHIO. Writing about *C. occidentalis* in Ohio, E. Lucy Braun (1961) pointed out that dwarf forms growing in shallow soil over limestone may be confused with *C. tenuifolia.* The reverse is obviously true as well, and indeed we discovered some examples of this confusion in our studies of herbarium collections. Braun recorded dwarf hackberry from only two counties in Ohio, Adams and Highland, both in the southern portion of the state. We can add later collections in Ohio from another southern county, Gallia. (Border of woods along Symmes Creek, Perry Twp., *Floyd Bartley* on 23 August 1964, OS). We are indebted to Ronald L. Stuckey and his assistant Marvin L. Roberts for providing on loan the Ohio State University collections of *Celtis.*

More interesting for the discussion here is a collection approximately 150 miles to the north and less than 10 miles from the shores of Lake Erie. This herbarium specimen (*G. T. Jones* on 22 August 1966, OS) came from

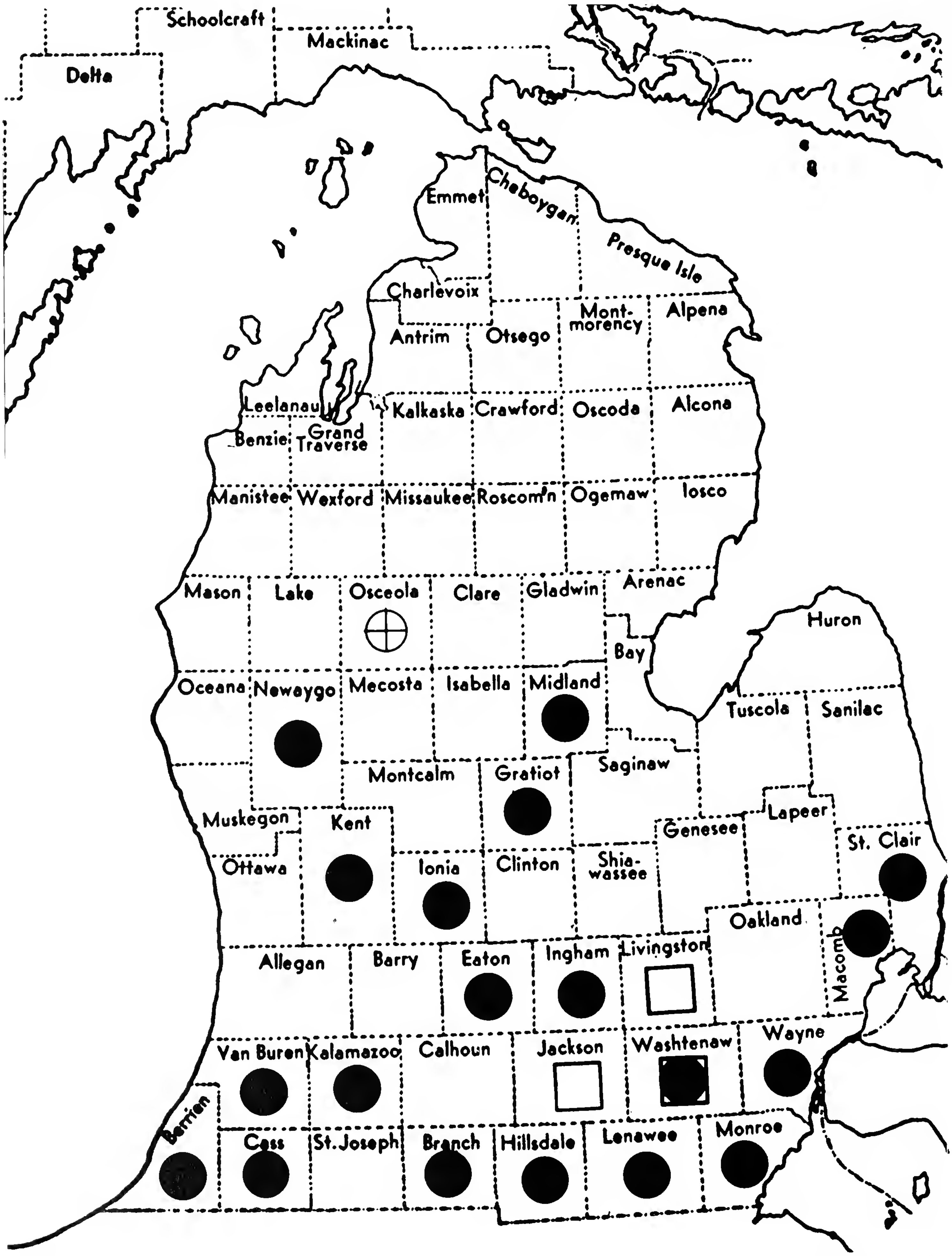

Fig. 3. County distribution in Michigan of *C. occidentalis* (dots; open dot = sight record) and *C. tenuifolia* (open squares), based upon herbarium collections.

Erie Co., Ohio, and was identified as *C. occidentalis*, presumably in the view that it was a dwarf form of that species. Examination of its critical characteristics (see enumeration in Table 2, below), revealed that it was *C. tenuifolia*, far from any previously recorded stations. Accordingly, we made a visit to the locality.

The area involved is referred to by Stuckey and Forsyth (1971) as the "Castalia-Bellevue-Sandusky Area," in connection with their investigations of the distribution of the limestone-associated nodding thistle, *Carduus nutans*. The bedrock here is Columbus Limestone and it is shallow enough to be exposed in natural or man-made cuts or to produce smooth, rounded hills. Here, with no difficulty, we found the dwarf hackberry to be locally frequent to abundant, growing primarily in old fields, edges of second-growth woods, and especially along fencerows. We did not explore the area thoroughly, but observed stands in Sandusky Co. (York Twp., *Wagner 73487*) and Erie Co. (Groton Twp., *73488*).

The major differences between the Michigan occurrences and those found in northern Ohio involve the substratum, the habits of the trees, and the plant associates. The substratum in the Ohio locality is glacial till, as it is in Michigan, but the bedrock is much closer to the surface. The hills are due to the conformation of the bedrock rather than morainal build-up. The trees of *C. tenuifolia* that we saw seemed to be somewhat taller on the average, and less irregular and more open in habit than those in Michigan. Although the common plant associations tended to be the same, there were several that we did not encounter in Michigan localities. Conspicuous among these were the following woody plants: *Cornus drummondii, Euonymus atropurpureus, Rhamnus lanceolata,* and *Maclura pomifera*. Because of the proximity of Lake Erie, this area has somewhat warmer temperatures than we find at the Michigan occurrences of *C. tenuifolia*.

A careful survey of the Sandusky-Castalia-Bellevue area will no doubt reveal more stations for this species than we observed on our short visit. Scattered also in this area are occurrences of *C. occidentalis* growing in upland sites, which make it an especially interesting area for observing the two species growing in association. *Celtis tenuifolia* is expected not only in Sandusky and Erie counties, but in Seneca and Huron counties as well (cf. Stuckey & Forsyth, 1971, pp. 6-9). It is conceivable too that dwarf hackberry will turn up where *Carduus nutans* is found in other areas of northern Ohio where limestone is close enough to the surface to simulate edaphic conditions like those in the Sandusky-Castalia-Bellevue Area.

INDIANA. In northern Indiana, *C. tenuifolia* occurs in two very distinctive habitats separated from each other a distance of approximately 100 miles. As in Ohio, this species is well known in the southern part of the state in the counties near the Ohio River, but we are not concerned with these here. The two northern Indiana localities are at the northeast and northwest corners of the state—glacial moraine and sand dune habitats respectively.

Deam (1921) reported dwarf hackberry from Steuben Co. at the northeast corner of Indiana. Charles B. Heiser kindly sent the data from the specimen (IND) on which the record was based: "A few gnarled trees about midway up the gravelly wooded slope on the east side of Hog Back Lake. Slope about 80 feet high. Trees 2-4 in. in diameter at the base, and 10-12 feet high. Fruit salmon at this date. Det. by B. F. Bush as *C. georgiana. C. C. Deam 30427*. August 29, 1920."

Well aware that many changes had taken place in the vicinity in the intervening years, including an enormous increase of cottages and resorts, we wondered whether the species still existed there. We drove, therefore, directly to the spot, which is approximately 4½ mi. west of the center of the town of Angola. We had no problem at all in finding plants; several trees grow along the roads, as well as on the steep banks above Hog Back Lake. Among the plant associates found there, most were like the common associates in Michigan, except for *Cercis canadensis*, *Corylus americana*, *Fraxinus americana*, *Lonicera japonica* (an introduced weed, now apparently spreading northward), *Morus alba*, and *Quercus muehlenbergii*, among the woody plants, and *Ambrosia trifida* (giant ragweed), among the herbs. The shoreline on the east side of Hog Back Lake has no doubt changed rather drastically since the time of Deam's collection as a result of road- and house-building there, but the plant has managed to persist. We also found a few roadside plants just east of the lake, suggesting that it is spreading, here as elsewhere, from the original natural areas into man-made habitats.

To check whether spread along roadsides was going on in the Angola area, we drove around various lakes following the dirt and paved roads. In the sector formed by Hog Back Lake in the south and Crooked Lake and Lake Gage in the north, we succeeded in finding roadside plants, some of them mere shrubs only a few feet tall but bearing abundant fruits. The best of the localities we discovered was between Orland Road and Third Basin Flats of Crooked Lake—a second-growth woods, where we observed over two dozen plants mature enough to bear fruits, some of them readily visible from the road. The Orland Road locality is approximately four miles north of Deam's original find. There will be, no doubt, additional spots in Steuben County where dwarf hackberry occurs, and it should also be sought in adjacent counties, including Branch Co., Michigan, where conditions are rather similar.

One of the peculiarities of the Angola area of Indiana is the relative abundance of the introduced white mulberry, *Morus alba*. Here it occurs in various habitats, and where it is found in open sites, it may come to resemble to a considerable degree the dwarf hackberry as seen in the winter.

In the Indiana dunes, *C. tenuifolia* ranges for about 15 miles here and there near the south shore of Lake Michigan. Hill (1900) wrote that "*C. pumila*" is found in the dry dune region "and is confined to a narrow belt extending east and west of the mouth of the Grand Calumet in Indiana, not yet seen beyond half a mile from Lake Michigan." Deam (1921) contrasted its occurrence along Lake Michigan ("dry sand dunes") with its occurrence in southern Indiana ("dry rocky slopes"); and Peattie (1930) described its incidence in the Lake Michigan area as "frequent on tops of bare high dunes from Mineral Springs westward . . ."

I was especially interested in studying dune occurrences of this tree, because of its obviously calcareous edaphic preferences in other localities where we had found it. It seemed to us that a sand substratum of dune derivation might be acidic, in view of the well known abundance of various ericads on wooded tops and slopes of these formations. I am indebted to Floyd A. Swink, taxonomist of the Morton Arboretum (Lisle, Illinois), for directing us to a place where we could observe dwarf hackberry growing on dunes. Swink's personal observations of this rare species were made during the 1940's "near the Grand Calumet River west of Lake Street (and thus west of Marquette Park), perhaps one-half mile south of Lake Michigan, growing in sand." We did not visit this locality, which is in Lake Co., and where Miller Beach is today, although Swink indicates (pers. comm.) that the plant could well still be there, as the area has not changed much over the past thirty years. Instead, using directions he supplied, we visited a locality where it was reported to occur at Dune Acres in Westchester Township, north of Chesterton, in Porter County—approximately the longitude of Peattie's eastermost extent of the range along Lake Michigan.[1]

Dune Acres is a private community located approximately two miles west of Indiana Dunes State Park. With permission of the marshall who has charge of policing Dune Acres, we travelled the roads there and discovered that dwarf hackberry trees were scattered widely over approximately one square mile. All of the trees we saw were visible from the roads, and most of them were growing directly along the roadsides, usually in sand, but sometimes, especially in flat areas, in richer, more stable soil. Along the tops of the more or less wooded slopes and not far from plants of the hackberry, we observed various acidophiles including *Vaccinium angustifolium, V. vacillans,* and *Gaultheria procumbens*. However, in no case did we find these species growing with or very near the dwarf hackberry. We tested the soil associated with the hackberry and found, once again, readings of pH 8.0-8.5. Where there was shifting sand close by, the sand tested slightly acidic. Sand directly under the plants gave readings of around 7.0.

As might be expected, some of the immediate associates in the dunes were quite different from those of the morainal areas. Among the distinctive dunes neighbors were *Andropogon scoparius, Elymus canadensis, Equisetum hyemale, Pteridium aquilinum,* and *Opuntia humifusa*. The more usual associates everywhere include *Celastrus scandens, Quercus rubra,* and *Robinia pseudoacacia*. Because of the more or less open and sandy nature of the habitats, the number of immediately associated species is relatively fewer than in the morainal occurrences we studied (see above). It should be emphasized, however, that here, as elsewhere, roadsides, roadbanks, and disturbed second-

[1]After studying the Dune Acres locality on 1 December 1973, we traveled up the Lake Michigan coast, making repeated forays into the dunes up to as far as Van Buren Co., Michigan, in the hope of discovering new stands of dwarf hackberry. However, we were unsuccessful, although some areas, especially in Berrien Co., Michigan, did look promising. Possibly further efforts to find this plant in the dunes of western Michigan will be rewarded by discovering populations.

growth woods are apparently ideal for the growth of these plants. Most of the dwarf hackberries were within one-third of a mile from the lake shore, and all were on the tops or lee sides of the dunes with the exception of a few in sandy flats. Out of a total of about 25 specimens seen, the tallest, growing on a steep sandy bank along East Road, was an irregularly formed tree ca. 28 feet in height.

ONTARIO. As early as 1916, C. K. Dodge reported *C. tenuifolia* in Lambton Co., Ontario. We are indebted to James H. Soper for his advice in the study of the Ontario occurrences. He wrote (7 September 1973) as follows: "I have records of the dwarf hackberry only from the Grand Bend to Pinery Park area . . .," and he notes that there are no other localities known in Ontario. The Lambton Co. localities are of special interest because they are much the farthest north among those so far reported; presumably the warming effects of Lake Huron enable the plant to occur this far north.

Pinery Park was set up to be a protected natural area, and therefore the populations there would be preserved. As Gaiser (1966) wrote, "An important step toward conservation was taken by the Provincial Parks Department when they decided to preserve the natural woods of a part of the sand dunes south of Grand Bend. In 1958, an area from the lake shore to the Blue Water Highway (#21)—an expanse over five miles long, almost bisected longitudinally by the Ausable River—was proclaimed as the Pinery Provincial Park." Interesting plants occur here, including excellent large stands of dwarf chestnut oak, *Quercus prinoides*; ram's head lady slipper, *Cypripedium arietinum*; and a number of Carolinian forest taxa, including the black maple, *Acer nigrum*; and tulip tree, *Liriodendron tulipifera*. Dwarf hackberry is actually not abundant in the park. Most of the occurrences are small and scattered.

As one drives northward to the park on route 21, the species is encountered first near the junction of Port Franks Road. Here dwarf hackberry grows along roads, on the flanks of more or less open dunes, and on the wooded crests. In the most open sites at the crests and sides of the dunes, the associated plants are very few in number of species, including, among the woody plants, *Quercus rubra, Rhus aromatica, R. glabra,* and *Vitis riparia*, and among the herbs, *Andropogon scoparius, Asclepias syriaca, Artemisia caudata, Elymus canadensis, Helianthus divaricata, Melilotus* sp., and *Poa compressa*.

Farther north by several miles, in Pinery Park, the dwarf hackberry appears on various sites. In the flat and sandy woodlands so common in the park, it is rare and sporadic, sometimes only a single isolated specimen. Associated with a solitary plant in this habitat we found *Amelanchier* sp., *Juniperus communis, J. virginiana, Pinus strobus, Quercus rubra, Rhus aromatica,* and *Toxicodendron radicans*. The most prominent ground plants at the time of our observations (4 December 1973) in these woods were the grass *Calamovilfa longifolia* and the fern *Pteridium aquilinum*. In such wooded sites, the plants grow up to eight feet in height, in contrast to those of the highly exposed dune situations, where the plants are extremely dwarfed, only growing to a maximum of three feet in height and very "bushy." In the exposed dunes the plants are also uncommon and sporadic. Growing with two of these very much dwarfed individuals of *Celtis tenuifolia* at the crest of a dune we found *Juniperus communis, J. virginiana, Quercus prinoides, Q. rubra, Pinus strobus,* and *Rhus aromatica*. The woody creeper, *Arctostaphylos uva-ursi*, was abundant here, as it is everywhere in the open dunes, as well as such herbs as *Andropogon scoparius, Artemisia caudata, Calamovilfa longifolia, Helianthus divaricata,* and *Smilacina stellata*. Occasionally—especially in protected, more shady valleys in the open dunes—the grape, *Vitis riparia*, becomes common and it may climb completely over a dwarf hackberry plant, seemingly smothering it.

In Pinery Park the greatest numbers of *Celtis tenuifolia* were encountered at a place pointed out to us by the naturalist, Harvey Smith—the huge Algonquin Dune located not far from the park entrance. Here, on the sparsely wooded slopes and crests of this ancient dune the species is abundant, although most of the plants are fairly small, being only 3-8 feet tall. One of the distinctive plant associates on Algonquin Dune is the round-leaved dogwood, *Cornus rugosa*.

It is interesting to note that all of the pH samples we collected in Pinery Park, as well as farther south along Port Franks Road, proved to have basic reaction, with pH = ca. 8.0, just as we found in all other occurrences of dwarf hackberry where we made tests.

COMPARISONS OF THE TWO HACKBERRIES

GEOGRAPHY. The Michigan county records of *Celtis tenuifolia* and *C. occidentalis* based on specimens at Cranbrook Institute of Science, Michigan State University, and University of Michigan are shown in Figure 3. *C. tenuifolia* is much less common and more narrowly distributed in the state than *C. occidentalis*. In over-all range, the former is southern, occurring most abundantly in the lower Mississippi Valley and Piedmont and Coastal Plain, while the latter is northern and montane. The range of *C. tenuifolia* is much more nearly congruent with that of *C. laevigata*, a species which reaches northward to northern Missouri, southern Illinois, and southern Indiana. The complete ranges of the two large-tree species, *C. occidentalis* and *C. laevigata*, are given by Little (1971, Map 121-E and 122-E). In the southeastern United States, we find *C. occidentalis* mainly as scattered populations in the Appalachian Mountains, while both *C. laevigata* and *C. tenuifolia* predominate in the Piedmont and Coastal Plain (Radford et al., 1968, p. 388).

The approximate overlap zone of the southern *C. tenuifolia* and *C. occidentalis* is illustrated in Figure 4. This map shows clearly the highly disjunctive nature of the Great Lakes populations of dwarf hackberry. Similarly disjunctive populations—not shown on our map—are found in *C. occidentalis*, these well to the south of its metropolis. These are tiny, localized populations in Mississippi, Alabama, and Georgia (cf. Little, 1971). The southerly outliers of *C. occidentalis* do not reach nearly as far south as the southernmost limits of *C. tenuifolia* (Louisiana to northern Florida). On

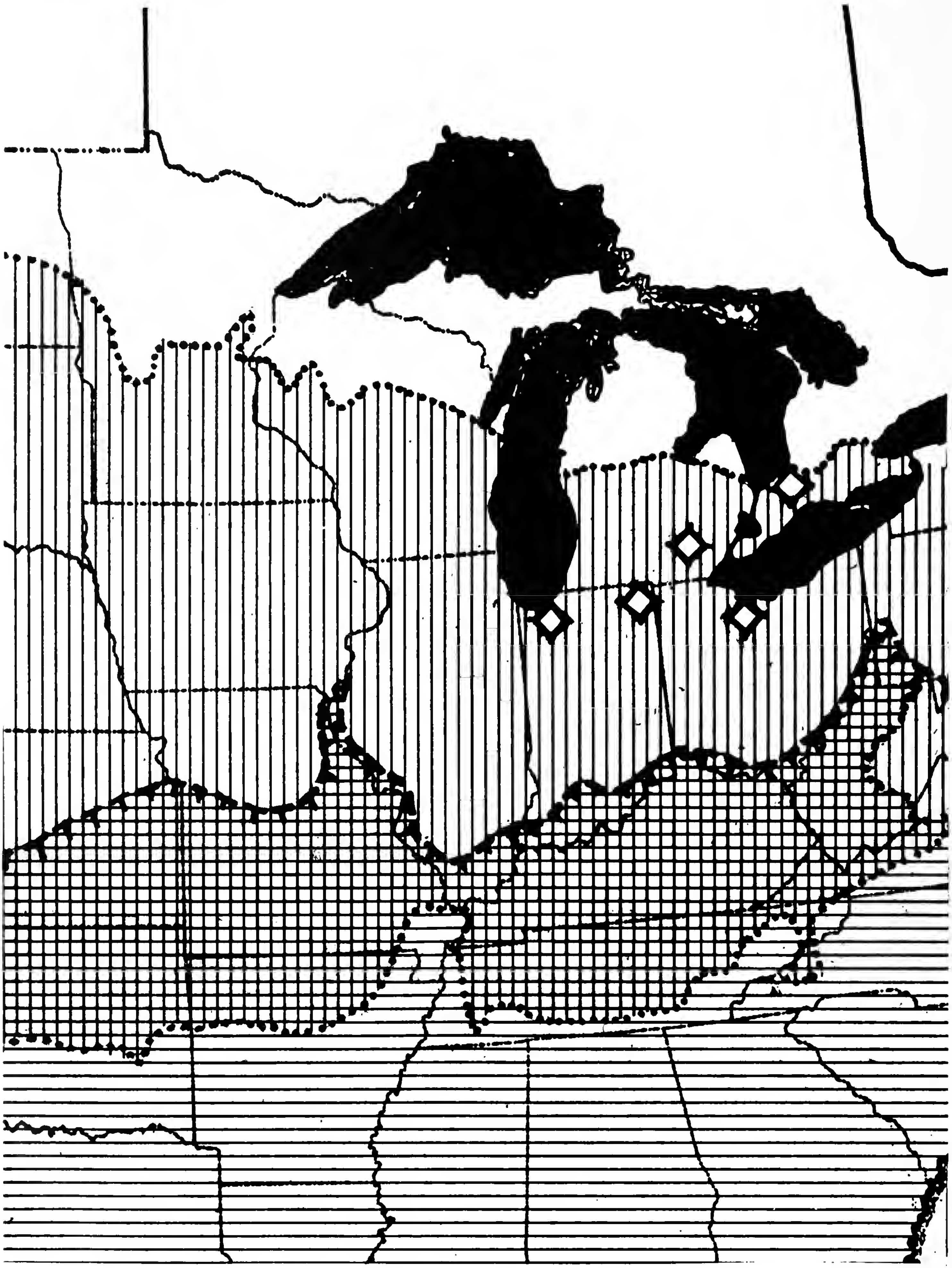

Fig. 4. Map showing range overlaps of *C. occidentalis* (vertical hatching) and *C. tenuifolia* (horizontal hatching). Note Great Lakes area disjunctions of the latter (open squares), well separated from the metropolis of that species.

the contrary, however, the northernmost stands of *C. tenuifolia* reach as far north as the maximum extent northward of *C. occidentalis*. (In Fig. 4, note especially the Lake Huron, Ontario, disjunction.)

HABITAT. The normal habitats of *C. tenuifolia* in the Great Lakes area are described above. It is an upland plant, growing mostly in the open, in soil which is well drained. The other species, *C. occidentalis*, is usually a plant of floodplain forests and nearby wooded hillsides. It is a lowland plant, growing mostly in the shade, in soil which is periodically flooded. *C. occidentalis* is also grown as a shade tree on occasion, because of its form, a broad crown with spreading branches. In general, *C. tenuifolia* has such a "scrubby" form that it is unlikely that this plant would be used for landscaping purposes.

To gain some idea of the associated species, I selected three Michigan localities where *C. tenuifolia* is common and three where *C. occidentalis* is common. I then recorded all woody plants growing within 25 feet of the respective species and all herbs within 15 feet. The time of observation was August and September, 1973. Certain broad outlines are evident from the data.[2] Approximately one-fourth of the taxa growing with *C. tenuifolia* are also associated with *C. occidentalis*, a total of 23. Most of these mutual associates are widespread, common species of woodlands and second-growth

TABLE 1. Woody plant associates of two hackberries in Michigan. The species here listed seem best to distinguish their most typical habitats respectively.

C. TENUIFOLIA	C. OCCIDENTALIS
Carya ovalis	Asimina triloba
Ceanothus americana	Carya cordiformis
Juglans nigra	Cercis canadensis
Juniperus virginiana	Cornus alternifolia
Lonicera tatarica	Euonymus atropurpurea
Pyrus coronaria	Gleditsia triacanthos
P. malus	Gymnocladus dioica
Quercus coccinea	Morus rubra
Q. prinoides	Platanus occidentalis
Rhus aromatica	Populus deltoides
R. glabra	Staphylea trifoliata
Sassafras albidum	Ulmus rubra

[2]The full results (approximately 100 associates for each species) are available upon request.

old fields. The woody species which seem most strongly to differentiate the communities in Michigan in which the two species are most prevalent respectively are compared in Table 1. If all or most of the species are found in a given habitat, the probabilities are very good of finding the associated hackberry.

It is interesting to note the high number of introduced species that occur in association with *C. tenuifolia*. This shows up especially in the herbaceous associates: Out of 55 taxa, 21, or nearly 40 per cent, are naturalized from the Old World. An additional seven species, including, for example, *Ambrosia artemisiifolia, Erigeron strigosus*, and *Plantago rugelii*, I interpret to be weeds also, but of American origin. A comparison with the list of herbaceous plants found with *C. occidentalis* in its floodplain habitats shows far fewer weeds.

Upland localities for *C. occidentalis* are much rarer than lowland. A notable one is found in the Warren Dunes area of Berrien Co., Michigan, where old forests have developed. Here we also find other floodplain species, such as red mulberry, *Morus rubra*, although the factors common to the two habitats, floodplain and wooded sand dune, are not particularly obvious. Probably the most common observation of upland plants of *C. occidentalis* involves individuals or colonies growing along roadsides, where, indeed, they may have been planted deliberately for shade or windbreak trees. A particularly fine example of the latter was found in Steuben Co., Indiana, where some huge, very old trees had generated a large colony running about 0.8 miles along a roadside bank (Co. rd. 550W, just north of 330N, *73492*); dozens of plants of all ages, including young saplings, were present.

It would be wrong to give the impression that upland stands of *C. occidentalis* are the result of planting entirely. As well differentiated as are the typical habitats for *C. occidentalis* and *C. tenuifolia*, there are, surprisingly, sites where they may grow near each other spontaneously, or even together in the same habitats. The latter situations are, of course, of great interest biosystematically, for they demonstrate that the peculiarities of the two taxa are genetically fixed and not environmentally induced. Pepoon apparently thought that *C. tenuifolia* was a mere environmental modification of *C. occidentalis*, and he wrote (1927, p. 281) of the plants at the Miller, Indiana, locality (which he called "*C. occidentalis pumila*") that they were "a curious example of the effect of soil and habitat to thus dwarf a stately tree."

Fox and Soper (1953) were the first to report co-existence of the two taxa in the same habitat in the Great Lakes area. These authors wrote as follows: "[*C. tenuifolia*] is found in Ontario only on the very limited tract of sand flats and dunes east and south of the last reach of the Aux Sables River in the northeast corner of Lambton Co. There it is found growing among tall mature specimens of its close relative, the Hackberry." In my studies I found two localities where *C. tenuifolia* grows together with *C. occidentalis*. In Erie Co., Ohio, the two species are found in association in hedgerows (Groton Twp., *73488, 73489*). In Washtenaw Co., Michigan, they grow with each other in a second-growth woodland (Sylvan Twp., *73462*).[3] Such localities were found to be excellent for comparing the two species; their numerous differences are strikingly maintained; and there is no evidence that soil and habitat have produced the differences, since the conditions are the same.

PARASITES AND GRAZERS. Preliminary observations of evidence of parasites on *C. tenuifolia* in comparison with *C. occidentalis* suggest that the latter is more susceptible. Few species of trees in the Great Lakes area show so much damage as *C. occidentalis*, especially in the second half of the summer and in the fall. The foliage commonly turns prematurely brown or yellow, presumably as a result of infestation by lace-bugs (Tingidae), these present sometimes in extraordinary numbers. The shoots are distorted by witches-broom disease, caused by gall-mites and powdery mildews (cf. Hepting, 1971, pp. 120-123). So prevalent are the witches-brooms with their irregular clusters of much-reduced twigs that field botanists use them for winter identification. The leaves of *C. occidentalis* are deformed by nipple-galls (*Pachypsylla celtidis-mamma* in the Chermidae; Felt & Rankin, 1932). Three well known butterflies are sought in the floodplain forests as their caterpillars feed upon the leaves of *Celtis occidentalis: Asterocampa celtis* (Langlois & Langlois, 1964), *A. clyton* in the Nymphalidae, and *Libytheana bachmannii* in the Libytheidae. These butterflies are generally regarded by collectors to be characteristic of the alluvial forest habitat along rivers and streams.

After examining many occurrences of both *C. tenuifolia* and *C. occidentalis*, it is my impression that the former is a much "cleaner" plant, with fewer evidences of diseases. Lace-bugs are rare or absent in late summer and fall; witches-brooms are usually absent; and nipple-galls are relatively infrequent. A number of times we encountered the remarkable tank-like caterpillar of the skiff moth (*Prolimacodes scapha* in the Limacodidae) on the leaves of *C. tenuifolia*, which seems to be a favorite host. To our surprise, all three of the hackberry butterflies were found associated with dwarf hackberry, flying in unexpectedly high, dry, and mostly open habitats.

MORPHOLOGY. Table 2 summarizes the main differences that we have found between the two hackberries in the Great Lakes area. Most of them

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[3]A list of conspicuous plant associates in the Washtenaw Co., Michigan, mixed locality follows: WOODY PLANTS–*Acer rubrum, Amelanchier* sp., *Carya ovalis, Cornus racemosa, Corylus americana, Crataegus* sp., *Fraxinus americana, Juglans nigra, Juniperus communis, J. virginiana, Ligustrum vulgare, Parthenocissus quinquefolia, Populus tremuloides, Prunus serotina, P. virginiana, Pyrus malus, Quercus alba, Q. prinoides, Q. rubra, Q. velutina, Rhus glabra, Robinia pseudoacacia, Rosa* sp., *Rubus occidentalis, Sambucus canadensis, Sassafras albidum, Smilax tamnoides, Tilia americana, Toxicodendron radicans, Ulmus americana, Vitis riparia*. HERBACEOUS PLANTS–*Anemone cylindrica, Asplenium platyneuron, Aster cordifolius, A. ericoides, Botrychium virginianum, Daucus carota, Dryopteris spinulosa, Monarda fistulosa, Poa pratensis, Solidago caesia, Urtica dioica*. Similar associates are found in an upland woods in Lyndon Twp., Washtenaw Co., Michigan, where *C. occidentalis* occurs alone (Lyndon Twp., Roe Rd., *73454*).

TABLE 2. Comparison of dwarf hackberry and northern hackberry.

CHARACTER	C. TENUIFOLIA	C. OCCIDENTALIS
Range	Mainly southern, to 36-37°N.	Mainly northern, to 41-42°N.
Habitat	Rocky bluffs, open woods, glades, fields, dunes.	Floodplain forest, rarely uplands.
Man-made disturbance	Common in old fields, roadsides, hedgerows	Common in natural floodplain situations.
Plant form	Shrub or irregular tree	Symmetrical tree
Average height	1-4 m [Max. 20 m Georgia]	6-15 m [Max. 35 m Michigan]
Branching	Compact, the branches numerous and intergrown	Lax, the branches fewer and more separated
Stems	Rigid, often spinelike	Pliable, not spinelike
Leaf orientation	Spreading in shade to diverse angles in open	Spreading to drooping, in shade or exposed
Blade shape	Ovate	Lanceolate
Blade texture (mature)	Coriaceous	Chartaceous
Blade tip	Acuminate	Attenuate-falcate
Blade base	Equal-sided to moderately asymmetrical	Strongly asymmetrical
Blade width	3.5 (2.2-4.5) cm	4.5 (3.0-5.5) cm
Blade length	4.8 (3.7-6.3) cm	8.8 (4.2-12.0) cm
Petiole length	0.45 (0.20-0.80) cm	0.93 (0.4-1.3) cm
Upper leaf surface	Veins impressed and forming linear depressions	Veins but slightly impressed.
Blade margin	Frequently entire at least in part	Uniformly toothed
Position of major areoles	Loops remote (2-4 mm) from margin	Loops close (1-3 mm) to margin
No. major areoles per side	3-5	5-8
Major areole shape	Broad, 2-5X as long as median width	Narrow, 4-9X as long as median width
Pedicel length	0.47 (0.30-0.60) cm (approx. same length as petiole)	1.4 (0.9-1.6) cm (longer than petiole)
Fruit shape	Globular	Subovoid
Fruit color (Aug.-Sep.)	Salmon	Olive-purple
Dried exocarp	Smooth and round	Deeply puckered, prune-like
Mesocarp flavor	Sweet, sugary	More tasteless, slightly bitter
Pit	Nearly round and smooth	Angled, with raised network of fine ridges
Fruit fall	Continuing until early spring	Mostly completed by October

require no special comment, so will not be discussed. A few do, however, call for some explanation or discussion, and these are taken up below.

The most conspicuous distinction between *C. tenuifolia* and *C. occidentalis* is the commonly dense, "bushy" habit of growth of the former. Plants, especially those of more open places, as they mature show the twigs densely intergrown, and almost spiny in texture. Hill (1900) described it well when he wrote, "Branches divaricate or much divergent, usually making a wide angle with their support, often a right angle or even slightly directed downward. They are scraggy, abundantly furnished with short twigs 3-10 cm. long, which frequently end in a stiff, leafless, thorn-like point, due to winter killing, and giving them the appearance of a thorn-bush." The compact arrangement of rigid, more or less sharp twigs suggests a possible protective adaptation in open barrens where grazing mammals might be discouraged from destroying the foliage because of numerous projections. In this connection it should be noted that in open areas and desert regions of the southwestern United States there occur hackberries of shrubby habit (e.g., *Celtis pallida* Torrey) which actually possess true spines. These are determinate lateral branches which produce leaves in the lower parts but end in hardened, pointed tips. As seen in winter from a passing car, *C. tenuifolia* in the Great Lakes area may frequently be confused with hawthorn, *Crataegus*, because of its dense habit of growth, and orientation of spine-like twigs.

As nearly as I can reconstruct the stages of growth of *C. tenuifolia*, it seems to be a matter of a long-persistent shrub stage, which may or may not be followed by a tree stage in which one or several trunks take over. The young saplings develop large tap roots up to a foot or more long and 1/3 to 2/3 inch thick. The shrubby stage may have 2-10 major branches from the ground. In extremely exposed sites the plant may not ever assume tree form, as on open sand dunes. The major branches simply become very thick and woody. But in the usual sites where we have found them, the plants, upon growing older, develop one or a few major trunks. The tallest individuals that we have observed in the Great Lakes are between 8 and 10 meters tall, very rarely more, although in the Southeast there are records up to approximately 20 meters tall. It is interesting to note that in the third edition of his *Trees of Indiana* Deam (1953) eliminated this species. Why this was done is not clear to me, but possibly he decided that it was a shrub and not a tree. If this were the case, it would be a mistake—for *C. tenuifolia* is both a tree and a shrub, depending on age and site. Furthermore, even though it is a small tree, it is as much a tree as is flowering-dogwood (*Cornus florida*) or blue-beech (*Carpinus caroliniana*) or others of our second-story arborescent species. *C. occidentalis* lacks the shrubby stage, except under unusual conditions of growth such as damage to the sapling trunk, and it normally forms a tall tree. The national record tree is a Michigan specimen from Allegan Co. (Wayland)—118 ft. tall with a crown 104 ft. across (Paul W. Thompson & G. Merren, in Pardo, 1973).

The measurements and shapes of leaves given in Table 2 and shown in Figures 5 and 7 are representative of plants in the Great Lakes area. As would be expected, leaves of both taxa when growing in shade tend to be larger than

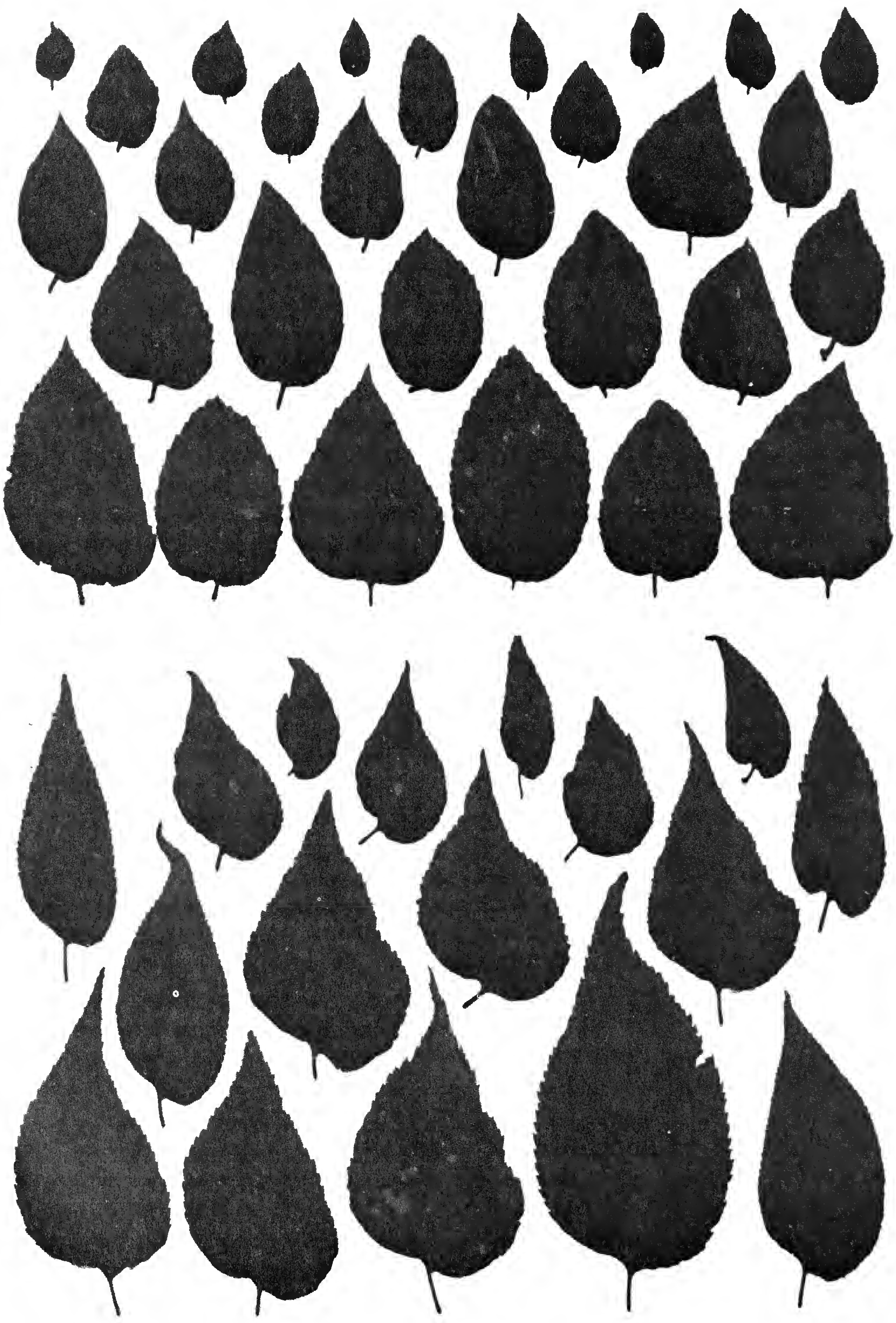

Fig. 5. Silhouettes of various sizes of leaves from several collections. *C. tenuifolia* above; *C. occidentalis* below. Note especially the form of the blade base and the blade tip. 0.4 × natural size.

those growing in the open. Also, in both species "sucker shoots" which may have remarkably large leaves are formed after injury. On one such individual of *C. tenuifolia* we found a few sucker shoots with stems 3 mm thick with leaves at intervals of 4-6 cm, the blades up to 12 cm long and 7 cm wide. Among the smallest-leaved forms of *C. tenuifolia* we have observed, some of those on the sand dunes in Lambton Co., Ontario, are notable (e.g., junct. rt. 23 and Port Franks Rd., *73497*); the leaf blade sizes here may average as little as 3.6 (3.0-4.5) X 2.5 (1.5-3.3) cm, or only approximately three-quarters the dimensions of the average for the species as a whole in the Great Lakes area.

One would expect from the larger leaf size of *C. occidentalis* that the winter bud would be correspondingly larger. In fact, Grimm (1957) uses this as a winter key character: "Buds 1/8 inch or more long" vs. "Buds less than 1/8 inch long." To test this, we made a number of collections of the two hackberry species where they grow together or near each other in Washtenaw Co., Michigan, on 11 December 1973, and measured over 100 buds of each. For the most part the "terminal" buds were damaged or absent, so the two top lateral buds were used. We did find a slight difference—an average of 2.65 mm length (range 1.0-3.2) for *C. tenuifolia*, and 2.95 (range 1.5-3.5) for *C. occidentalis*, but we felt that there was too little difference and too much overlap for this to be at all useful as a character for discriminating the taxa. We therefore did not include bud length on the chart.

The leaf outlines shown in Figure 5 are typical. Leaf outline alone, however, does not fully express the extent of foliar differentiation between our hackberries, as is itemized in Table 2. The blade texture differs sharply. Both species start out the season with soft-textured, herbaceous leaves, as do all of our deciduous species of woody plants. Dwarf hackberry is indeed tenuifolious for the first month of the growing season, but soon becomes crassifolious when all the tissues have matured and hardened. (One wonders whether the inappropriate epithet "tenuifolia" was not applied to specimens collected early in the season.) Dead leaves of *C. tenuifolia* lying on the ground during the late fall and winter tend to curl only slightly when dried out, but those of *C. occidentalis* obtained at the same time and treated the same way tend to roll up completely.

We had hoped to find differences in the hairs and their distribution in the two species, but the variability of the indument of the leaves of numerous collections was such that there was complete overlap. *Celtis occidentalis* is especially variable in this respect. Part of the textural difference between *C. tenuifolia* and *C. occidentalis*, at least in the Great Lakes area, is due to the surface sculpture of the upper blade surface as shown in Figure 6. In *C. tenuifolia* the surface shows the patterns of the main veins clearly because there are narrow channels running above them. The primary areoles are especially marked in this species (as shown in Fig. 6, a-m), in sharp contrast to those of *C. occidentalis*.

Frequently the margins of *C. tenuifolia* are partially or wholly entire. If partially entire, the teeth are confined to the upper half. Both types are shown in Figure 7, A and C, vs. B and D, and in Figure 5. Sometimes on a

Fig. 6. Shoots of *C. tenuifolia* from same plant showing different leaf forms—entire-margined and dentate-margined. Note sculpture of upper leaf surface with vein pathways sunken.

tree with otherwise tooth-margined leaves, a single shoot will be made up exclusively of entire-margined leaves (Fig. 6). Fernald's (1950) distinction that only "leaves of fertile branchlets [are] entire or very sparingly toothed" does not hold up in Great Lakes materials. Although the most entire-leaved forms we have found came from Sandusky Co., Ohio (*73487*), we have not found any localities where they are absent completely. In contrast, we have found no such forms at all in *C. occidentalis*.

Together with the other differences, the venation patterns of the species respectively strongly fortify the conclusion that the leaves are probably the best means of separating them. The major contrasts involve the primary areoles, their shape, number, and relation to the blade margin. The micro-projector tracings of cleared leaves shown in Figure 7 are confined to the major veins. In contrast to elm leaves, which are "simple craspedodromous," those of hackberries are "brochidodromous" (terminology of Hickey, 1973). In elm, the veins run directly to the margin, while in hackberry they form loops; in Hickey's classification the latter is expressed as "secondaries joined together in a series of prominent arches." The point here is that *C. tenuifolia* has much more prominent arches than *C. occidentalis*. They are fewer in number, broader, and do not reach so close to the margin, so they are more conspicuous. In *C. occidentalis*, the leaves appear somewhat more like those of elms (e.g., *Ulmus americana, U. pumila*) because the arches are less evident, being closer to the margin and made up of more delicate veins; also there are

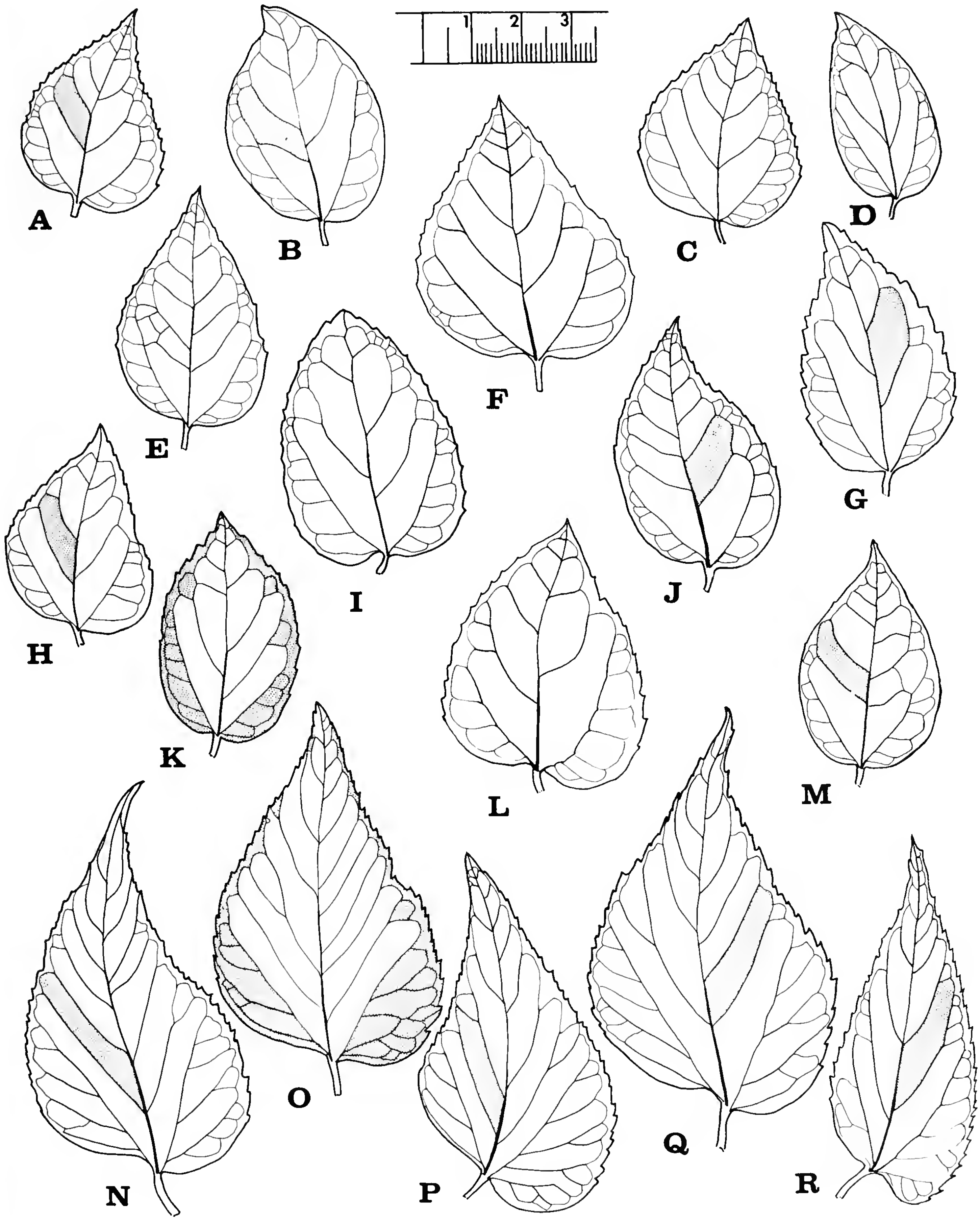

Fig. 7. Leaf clearings of hackberries traced to show the major veins. A-M: *C. tenuifolia*. N-R: *C. occidentalis*. Areoles and marginal blade areas stippled to emphasize areole number, shape, and position in relation to margin.

more numerous lateral secondary veins, again as in elms. In living plants, the arches of *C. occidentalis* are hardly, if at all, evident without very careful examination.

The fruits provide valuable distinctions between the two hackberries, but unfortunately they are present in only certain individuals, and in *C. occi-*

dentalis they have usually fallen by October. In addition to differences of pedicel length, fruit shape, and color, the fruits of *C. tenuifolia* remain plump and smooth upon drying, while those of *C. occidentalis* become wrinkled like a prune, as shown in Figure 8. Some people like to eat the "berries" (actually drupes) for their sweet flavor. These "sugarberries" provide very little to eat, being occupied mainly by the hard pit or stone, but presumably birds find them attractive and through their movements disperse the seeds. There is a flavor difference between the species, which is rather difficult to verbalize.[4]

I have not illustrated the difference between the pits of the two species because it was done for plants of the Great Lakes area nearly three-quarters of a century ago in the beautiful figures of Hill (1900) based on specimens from the Chicago region. The endocarp is readily removed from dried fruits by soaking

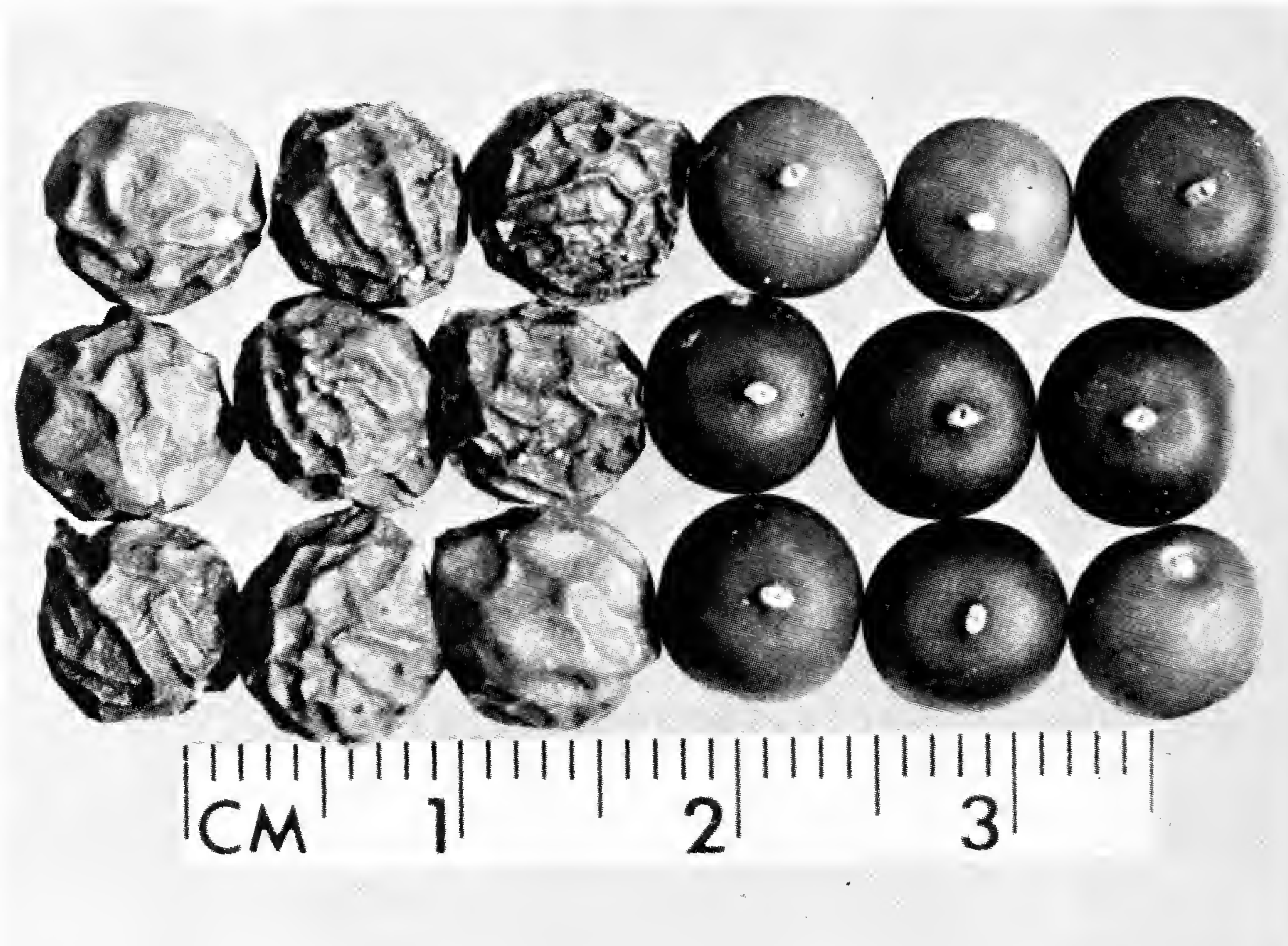

Fig. 8. Mature drupes of hackberries collected in late August and allowed to dry. *Left: C. occidentalis. Right: C. tenuifolia.*

[4]I asked nine persons to eat mature drupes of the two species freshly collected in September, and compare their impressions of their flavors. All agreed that the fruits of *C. tenuifolia* were sweeter (e.g., "more flavorful," "sweet like an eating apple," "better tasting," "sweet throughout," "somewhat like dates," "sweet grapey taste," "initial sour-acid taste followed by a sweet aftertaste"). The fruits of *C. occidentalis* are generally unpleasant to eat, according to the individuals reporting (e.g., "about as exciting as chewing a maple leaf," "mildly acid," "bland at first, somewhat bitter," "like an unripe apple," "less flavorful, more 'papery', dully bitter").

in detergent and scraping off the meso- and exocarp. When cleaned, the pits of *C. tenuifolia,* as illustrated by Hill, are seen as smaller, smoother, and paler. Those of *C. occidentalis* are larger over-all, longer in outline, with conspicuous angles, between which are definite reticula of darkly colored, fine ridges. (Hill also shows the stones of the western *C. reticulata* Torr. and "*C. mississippiensis* Bosc" = *C. laevigata* Willd., both of which are more similar to *C. tenuifolia* than to *C. occidentalis*).

DISCUSSION

Dwarf hackberry, *Celtis tenuifolia*, is now known in five highly disjunctive areas far north of its metropolis: (a) the Indiana Dunes (Lake and Porter Cos., Ind.); (b) Angola area, n.e. Indiana (Steuben Co.); (c) Jackson-Brighton-Pinckney area of s.e. Michigan (Jackson, Washtenaw, and Livingston Cos.); (d) Sandusky-Castalia-Bellevue area of n. Ohio (Sandusky and Erie Cos.); and (e) the Grand Bend-Port Franks area of Ontario (Lambton Co.). Two of these—that in Michigan and that in Ohio—are reported here for the first time. From the standpoint of geography, these northern localities have three notable features: (1) They are all well north of the southern border of glaciation in the Wisconsin stage (Pleistocene Epoch, cf. Little, 1971, overlay 8-E). The range of *C. tenuifolia* otherwise is entirely south of this line, extending to the Gulf states and northern Florida. The disjunctive populations of *C. tenuifolia* have been given little attention by writers of standard manuals (e.g., Fernald, 1950; Gleason, 1952). (2) The bulk of the range of *C. tenuifolia* lies in the standard Hardiness Zones of 6 through 8, with average annual minimal temperatures ranging from −10°F to +20°F. Even recognizing the arbitrary boundaries between the intergrading temperatures, we can gain some idea of hardiness conditions by comparing them. The coldest winter temperatures of the populations near the shores of Lake Michigan, Lake Erie, and possibly Lake Huron place them in Hardiness Zone 6, even they are far to the northward of this zone proper. For two of the populations, however—those in Michigan and northeastern Indiana—the coldest winter temperatures are those of Hardiness Zone 5, i.e., −20°F to −10°F. (3) The northern localities are, so far as our present knowledge indicates, scattered very sporadically over a wide area of southern Ontario, southern Michigan, northern Ohio, and northern Indiana. Perhaps future awareness by botanists and naturalists of the characteristics of dwarf hackberry will change this picture by showing that it is actually more widespread and continuous in its northern distribution than we believed.

The habitats of *C. tenuifolia* are found in three main geological situations, namely (a) sand dunes, especially on partially wooded slopes and sand flats; (b) rolling glacial moraines; and (c) limestone areas where the bedrock is near the surface. The soil reactions of the topsoil directly below the plants are decidedly basic, even on sand dunes. The plant is successional, and presumably will be eliminated by mature oak-hickory forest where the natural succession can proceed. I believe that in many ways the results of man's activities have stimulated the development of dwarf hackberry, as some of the best stands are found in old fields, old orchards, fencerows, and roadbanks. In the various Great Lakes habitats the neighboring plants vary greatly, and the most faithful associates are, for the most part, common and broadly tolerant. A large number of introduced and native weedy species occur in association with dwarf hackberry.

Celtis tenuifolia has not been found to grow in the alluvial forest habitat so characteristic of *C. occidentalis*, but *C. occidentalis* may grow in upland habitats of *C. tenuifolia*, although rarely. The most common habitat of *C. occidentalis* is strongly different from that of *C. tenuifolia* in terms of location by rivers, structure of vegetation, and associated plant species.

There is no question in my mind that *C. tenuifolia* merits recognition as a species distinct from *C. occidentalis*, in spite of the fact that they have been confused with each other or have been treated as only varietally distinct. As shown above (Table 2) there are over two dozen distinctions between them. Of these, the details of leaf structure, and in particular the venation patterns, are particularly convincing differences. Evidently the nature of the brochidodromous venation patterns in the two species has not previously been clearly delineated by authors. Although a number of the distinguishing characters may overlap, their central tendencies are significantly different.

As to how to treat these plants taxonomically, I suggest, on the basis of our studies of Great Lakes populations, that they have, perhaps, been overly "taxonomized." The enormous amount of variation that we have seen both in *C. tenuifolia* and in *C. occidentalis*—sometimes on branches of the same plant!—indicates that they are polymorphic and that the different expressions do not lend themselves to classification as true varieties, at least in the Great Lakes area and perhaps generally. One of the essentials of true varieties (or "subspecies," in one common usage), it seems to me, is that they possess geographical distinctness, i.e., that their characteristics are correlated with definite areas. That this is not necessarily true in hackberries is rather nicely demonstrated, I believe, by the range maps given by Steyermark (1963, pp. 556-560, 562) for the state of Missouri. For var. *occidentalis*, var. *pumila* (Pursh) Gray, and var. *canina* (Raf.) Sarg. of *C. occidentalis*, I can detect no pattern of distribution at all; all of the "varieties" seem to be scattered more or less equally across the state, with the possible exception of var. *pumila* (missing or not yet recorded from the bottom counties of the state). The same is true of the so-called "varieties" of *C. tenuifolia.* Steyermark has var. *tenuifolia* and var. *georgiana* (Small) Fern. and Schub. randomly intermixed in range in all directions.

To add to the problem of hackberry nomenclature, there was for many years confusion about the application of the names. This problem was dealt with by Fernald and Schubert (1948), who studied type specimens in British herbaria. Their treatment of the names is followed today by most authors, and the main taxonomic question in the eastern United States involves whether or not to recognize varieties, as indicated above. In the Great Lakes area, I cannot find justification at this time for varietal separations, either in *C. tenuifolia* or in *C. occidentalis.* Two varieties of the former were based upon Indiana and Ontario materials: var. *deamii* Sargent and var. *soperi* Boivin, respectively. I cannot, however, recognize these varieties because of the variation I have encountered, and the lack of significant pattern. A somewhat different statement of the problem is that by Little (1953) who wrote as follows: "*Celtis* is a difficult genus with intergrading forms as well as ecological variations. Since the species are not well defined, it seems unnecessary to distinguish minor variations as varieties."

Some of the taxonomic problems of *Celtis* can be solved by intensive field work, especially field work focused on studying mixed populations. The fact that we find in three different areas of the Great Lakes region mixed populations including both *C. tenuifolia* and *C. occidentalis* provides very strong support for their specific distinction. Their taxonomic distinctions are maintained and there is no intergradation. One cannot agree, therefore, with Radford et al. (1968) who place the two taxa as varieties of a single species.

If we accept the proposition that there are three distinct species of hackberries in eastern United States—*C. occidentalis*, *C. tenuifolia,* and *C. laevigata*—what should be their English names? These are important native plants, for which teachers, lecturers, public relations officers, and environmentalists need non-Latin names for communication. All I can find is confusion, with over 20 variously applied names. As Krajicek, a forester, points out (1958) in regard to *C. occidentalis*, "A related species, sugarberry (*C. laevigata* Willd.) is commonly called hackberry . . ." In fact, for this reason, he was unable to determine accurately the southern range extension of *C. occidentalis* from reports in the literature. All three species are called "sugarberry," and all three are called "hackberry."

According to Fernald (1950) the French name of *C. occidentalis* in Quebec is "bois inconnu." Evidently, this plant was hard to fit into the scheme of trees familiar to immigrants. Some of the names, however, have considerable taxonomic interest for the relationships suggested. H. N. Moldenke gathered together some of these names (*Moldenke 13517,* OS). In addition to the familiar "hackberry," (from "hagberry," etymology given in dictionaries), he listed "common hackberry" and "sugar-berry," as well as such names as "beaver-wood," "juniper-tree," and "one-berry." Some of the names he listed seem quite fanciful, such as "hoop-ash" and "rim-ash" (wood similar to ash?). Such names, however, as "bastard-elm" and "false elm" are, of course, not far off the beam systematically. Most intriguing is the name "nettle-tree" which suggests a folk recognition of taxonomic relationships at the ordinal level (Urticales). *Celtis laevigata*, in addition to many of the English names given to *C. occidentalis* is also called "sugar hackberry," "Texas hackberry," and "Southern hackberry" (Little, 1953; Steyermark, 1963). Among names for *C. tenuifolia* which have been reported to me by natives or gleaned from the literature, I have "dwarf hackberry," "small sugarberry" (Dodge, 1916), "sugarberry," "wolfberry" (Ozarks), "monkey nuts" (Ozarks), and "Georgia hackberry" (s.e. U.S.).

In one of the most popular manuals for trees and shrubs of eastern United States, Petrides (1958) gives English names which differ from *all* of those given above. These are "American hackberry" (= *C. occidentalis*), "Lowland hackberry" (= *C. laevigata*), and "Upland hackberry" (= *C. tenuifolia*). As will be seen from the facts presented in this paper, these names do not altogether characterize the plants.

I propose that the standardized English names for the three hackberries be as follows:

C. occidentalis = Northern hackberry
C. laevigata = Southern hackberry
C. tenuifolia = Dwarf hackberry

Justification for designating the "Northern" and the "Southern" is seen in the range maps of Little (1971) and especially those of Brockman (1968, see p. 142).

ACKNOWLEDGMENTS

I wish to express my thanks to the many students who helped in making this study. Also, I wish to thank Mrs. Janice Glimn Lacy, my assistant, who provided valuable help in processing vouchers and preparing plates, and Dr. Burton V. Barnes, my colleague in the School of Natural Resources, for many stimulating discussions of problems of woody plants in the Great Lakes area.

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Publications of Interest

From time to time we call attention, under this heading, to new publications which might be of particular interest to some of our readers but which, because of less explicit geographic or botanical orientation, do not qualify for regular review or inclusion in "Michigan Plants in Print." All annotations are by the Editor unless ascribed to another.

The several publications of the Ohio Biological Survey noted below may be obtained from the Survey at 484 West 12th Avenue, Columbus, Ohio 43210 (checks payable to Ohio Biological Survey; Ohio residents add 4% sales tax).

BIBLIOGRAPHY OF AQUATIC FLOWERING PLANTS OF OHIO. By Ronald L. Stuckey. Ohio Biol. Surv. Informative Circ. 2. 1973. 11 pp. $.50. A bibliography organized by taxa and by areas (including Lake Erie).

A GUIDE TO THE LITERATURE OF OHIO'S NATURAL AREAS. By Lynn Edward Elfner, Ronald L. Stuckey, and Ruth W. Melvin. Ohio Biol. Surv. Informative Circ. 3. 1973. 56 pp. $.50. An extensive bibliography, organized by county and natural areas within each county.

THE VASCULAR FLORA OF GLEN HELEN, CLIFTON GORGE, AND JOHN BRYAN STATE PARK. By Sture F. Anliot. Ohio Biol. Surv. Biol. Notes 5. 1973. 162 pp. $3.00. Includes a well illustrated discussion of the geological setting and vegetation of one of Ohio's finest and best known natural areas, followed by an annotated list of the 872 species of vascular plants recognized in the state park, adjacent Glen Helen (belonging to Antioch College), Clifton Gorge Nature Preserve, and certain private properties in the study area, along the Little Miami River in southwestern Ohio. (Your editor hiked the length of this area in 1967 and found nothing not included in what appears to be a very thorough list.)

THE EFFECTS OF ECOLOGICAL CHANGES ON BUCKEYE LAKE, OHIO, WITH EMPHASIS ON LARGEMOUTH BASS AND AQUATIC VASCULAR PLANTS. By John Bayless Judd and Stephen H. Taub. Ohio Biol. Surv. Biol. Notes 6. 1973. 51 pp. $1.50. Contains considerable information on the history, limnology, and vegetation of a lake which was impounded almost 150 years ago in "a cranberry-sphagnum bog-swamp." Originally built to serve as a water supply for the Ohio-Erie Canal, the lake is now used intensively for recreation. The extent and quality of higher aquatic vegetation is now decreased.

WILDERNESS POCKET N' PAK LIBRARY. Life Support Technology, Inc., Manning, Oregon 97125. 1969-71. 5 64-page vols. $4.95. We are asked to inform our readership about this compact 3¾ × 4¾ inch "library" in a "convenient accordian[sic]-folded vinyl pack." This we do, but without recommendation. Two of the little volumes are on Edible Plants in the Wilderness, one is on Poisonous Plants in the Wilderness, one on Survival in the Wilderness, and one on Primitive Medical Aid in the Wilderness. Worthy subjects all, but despite the over-impressive name of the publisher, the contents are of very uneven quality, marred by abundant typographic, spelling, and factual errors. Because the geographic scope seems to be nearly world-wide, it may be hard to find information applicable to the Great Lakes region, where a monkey is rarely available as a guide to edibility of strange plants, where seaweed is unavailable for food or first aid, where it is irrelevant that only 200 kinds of snakes in the world are dangerous to man (we have but one). Here, in fact, it is dangerous to read that "all" varieties of poison ivy "twine poles or trees" (our commonest variety never does) or that *Zigadenus* grows "in the western U.S. and Canada." The plant illustrated and described in the "Medical" Book as "plantain" is *Plantago lanceolata,* as given in the "Edible" Book 2, not the totally unrelated *Alisma plantago[-aquatica],* as cited. For persons who do not know the plants referred to, the information given is generally inadequate for identification; for those who do know something about elementary botany, it is too often frustratingly inaccurate with reference to stems, leaves, roots, etc., as well as omission of significant key characters and helpful data on geographic occurrence. Sequence of plants in the two "Edible" volumes is alphabetical by the first common name chosen by the authors–i.e., nearly random (and there is no index). The volumes are available separately at $1.00 each, and this may explain the considerable repetition, although it is still not clear why the "Survival" volume needs to repeat exactly on pp. 55-56 the information about the compass given on pp. 54-55 of the same volume! Pocket-sized guides of this sort if prepared with more care and less haste, and oriented to specific parts of the country, could be very useful.

ASPEN Minnesota's No. 1 Tree. By George, Allen, and Bob Rossman. Northprint Co., Grand Rapids, Minnesota 55744. 1972. 31 pp. Colorfully illustrated booklet on the biology of aspens and their commercial use.

(More on page 103)

MICHIGAN PLANTS IN PRINT

New Literature Relating to Michigan Botany

This section lists new literature relating to Michigan botany under four categories: A. Maps, Soils, Geology, Climate (new maps and selected bulletins or articles on matters useful to field naturalists and students of plant distribution); B. Books, Bulletins, etc., and C. Journal Articles (listing, respectively, all separate publications and articles in other periodicals which cite Michigan specimens or include research based on plants of wild origin in Michigan—not generally including work on cultivated plants nor strictly economic aspects of forestry, conservation, or agriculture); D. History, Biography, Exploration (institutions as well as travels and lives of persons with Michigan botanical connections). When the subject matter or relation to Michigan is not clear from the title, annotations are added in brackets. Readers are urged to call to the editor's attention any titles (1960 or later) which appear to have been overlooked—especially in less well known sources.

—E. G. V.

A. MAPS, SOILS, GEOLOGY, CLIMATE

Bujnowski, Bernard, & Louis F. Twardzik. 1971. A Look at Michigan Climate: Winter Recreation Developments. Mich. St. Univ. Ext. Bull. E-715. 8 pp. [Includes bar graphs giving climatological data for Alpena, Escanaba, Detroit, Grand Rapids, Lansing, Houghton Lake, Muskegon, Flint, Sault Ste. Marie, and Marquette; and maps showing for the state average snowfall, normal annual precipitation, and average dates of first and last freezing temperatures.]

Carmean, Willard H. 1973. Forest Soils Bibliography for the North Central Region (Including Subject Matter Index through 1972). North Central For. Exp. Sta., U.S. For. Serv. Gen. Tech. Rep. NC-5. 68 pp. [Lists 793 titles dealing with forest soils. Includes index by area (ca. 75 references for Michigan) and subject-matter.]

Hendrickson, G. E., & C. J. Doonan. 1972. Reconnaissance of the Manistee River, a Cold-Water River in the Northwestern Part of Michigan's Southern Peninsula. U.S. Geol. Surv. Hydrol. Invest. Atlas HA-436. 2 sheets. $1.00. [Another thorough river report in the series previously noted in these listings.]

Huber, N. King. 1973. Glacial and Postglacial Geologic History of Isle Royale National Park, Michigan. U.S. Geol. Surv. Prof. Pap 754-A. 15 pp. + map. $1.00. [Thoroughly illustrated with maps, diagrams, and photos.]

Pregitzer, Karl E. 1972. Soil Survey of Ottawa County, Michigan. U.S. Dep. Agr. 139 pp. + 71 once-folded map plates + 5 folded legends, etc. $5.95. [Includes complete 1968 aerial photographic coverage for the county, on a scale of about 4″ to a male, with boundaries of soil types superimposed. Both the text and the photographic coverage will be invaluable to field botanists in the county, for which an old (1922) soil survey was obsolete.]

(U.S. Geological Survey). The following topographic maps for Michigan have been published since the previous listing in our January 1973 issue and are available at $.75 each from Branch of Distribution, U.S. Geological Survey, 1200 South Eads Street, Arlington, Virginia 22202. (The only discount now allowed, 30%, is on orders of $300 or more.) Maps are supplied with green overprint showing woodland unless request is made to the contrary. All maps listed here are 7½-minute quadrangles (scale of 1:24,000 or about 2½″ to a mile) and are new or resurveyed, except for those marked with an asterisk, which are photorevisions. Following the name of the quadrangle, the county or counties in which it primarily lies are added.

Allendale* [Ottawa]
Augusta* [Kalamazoo, Calhoun]
Bad Axe East [Huron]
Bad Axe SE [Huron]
Bad Axe West [Huron]
Banfield* [Barry, Kalamazoo, Calhoun]
Baroda [Berrien]
Battle Creek* [Calhoun]
Bay Port East [Huron]
Bay Port West [Huron]
Bedford* [Barry, Calhoun]
Bellevue* [Calhoun, Eaton, Barry]
Benton Harbor [Berrien]
Benton Heights [Berrien]
Berrien Springs[Berrien]
Bridgman [Berrien]
Caledonia* [Kent]
Caseville [Huron]
Cedar Springs* [Kent]
Cedar Springs SW [Kent]
Cement City [Jackson, Lenawee]
Ceresco* [Calhoun]
Charity Island [Arenac]
Coloma [Berrien]
Cutlerville* [Kent]
Dansville [Ingham]
Delton* [Barry, Kalamazoo]
East Lansing [Ingham]
Elkton [Huron]
Galesburg* [Kalamazoo]
Galien [Berrien]
Gilletts Lake [Jackson]
Grand Rapids East* [Kent]
Grand Rapids West* [Kent]
Grandville* [Ottawa, Kent]
Harbor Beach [Huron]
Huron City [Huron]
Jackson North [Jackson]
Jackson South [Jackson]
Kinde East [Huron]
Kinde West [Huron]
Leslie [Ingham, Jackson]
Long Lake NE [Iron + Wisconsin]
Mason [Ingham]
Michigan Center [Jackson]
Niles West [Berrien]
Pleasant Lake [Ingham, Jackson]
Port Austin East [Huron]
Port Austin West [Huron]
Port Hope [Huron]
Redman [Huron]
Rockford* [Kent]
Rush Lake [Huron]
Sand Point [Huron]
Sodus [Berrien]
Somerset Center [Jackson, Hillsdale]
Sparta* [Kent]
Three Oaks [Berrien]
Tipler [Iron + Wisconsin]
Williamston [Ingham]

C. JOURNAL ARTICLES

Kimbrough, James W., E. R. Luck-Allen, & Roy F. Cain. 1972. North American species of Coprotus (Thelebolaceae: Pezizales). Canad. Jour. Bot. 50: 957-971. [*C. glaucellus* cited from Cheboygan Co.; *C. leucopocillum* (sp. nov.), from Isle Royale.]

Murry, Lynn E., & W. Hardy Eshbaugh. 1971. A palynological study of the Solaninae (Solanaceae). Grana 11: 65-78. [Some of the material studied of *Lycium halimifolium* and *Physalis grandiflora* was herbarium collections from Michigan.]

Pardo, Richard. 1973. AFA's social register of big trees. Am. Forests 79(4): 21-47. [This listing of the largest reported specimens of the native and planted trees of the U.S. includes 52 national champions from Michigan—a record second only to that of Florida thanks to the MBC Big Tree program. The names of Paul Thompson and Harold Nett are prominent among the nominators in this list!]

Stephenson, Stephen N. 1973. A comparison of productivity and diversity in early and late season oldfield plant communities. Mich. Academ. 5: 325-334. [Study conducted on fields at the Michigan State University campus.]

Thorne, Robert F. 1972. Major disjunctions in the geographic ranges of seed plants. Quart. Rev. Biol. 47: 365-411. [*Oplopanax horridus* mentioned from Isle Royale.]

Van Faasen, Paul, & Fern Frank Sterk. 1973. Chromosome numbers in Aster. Rhodora 75: 26-33. [Includes counts on *A. pilosus, A. ciliolatus,* and *A. simplex* from Michigan localities.]

Widén, Carl-Johan, & Donald M. Britton. 1971. A chromatographic and cytological study of Dryopteris dilatata in North America and eastern Asia. Canad. Jour. Bot. 49: 247-258. [Refers to the "Lake Superior diploid" reported by Wagner and Hagenah from Michigan.]

Editorial Notes

Exciting plans are under way for the 1974 campout of the Michigan Botanical Club May 24-27. A diversity of field trips from the headquarters at the M.S.U. Biological Station on Gull Lake will give members an opportunity to see many areas of botanical interest in southwestern Michigan. Watch for details soon.

SUBSCRIPTIONS RISE. As already recorded on the inside front cover, inflation has forced us to increase our income. The costs of printing, paper, and postage are rising dramatically. Effective with Vol. 14 (1975) the annual subscription rate for THE MICHIGAN BOTANIST will be $5.00. (That will be eight years after the previous increase.) Members of the Botanical Club will continue to receive the journal as one of the privileges of membership, but membership dues will also have to rise. Back issues through Vol. 13 will remain at $3.00 per volume, when available. Page charges, for all pages in excess of 10 in any one article, have been raised to $20.00, effective with manuscripts received in February 1973.

Except for the increase in charges for excess pages, the "Information for Authors" printed on p. 142 of the March 1973 issue remains relevant. Prospective authors are urgently requested to study that page. We receive entirely too many manuscripts which fail to doublespace *everything,* which use "erasable" types of paper, which are not provided in duplicate, and/or which do not follow the style of this journal. Such manuscripts will receive relatively low priority for editorial action.

The January number (Vol. 13, No. 1) was mailed January 16, 1974.

Publications of Interest

COMPREHENSIVE PLAN FOR THE ILLINOIS NATURE PRESERVES SYSTEM Part 1–Guidelines. Illinois Nature Preserves Commission, 819 North Main St., Rockford, Illinois 61103. [1972] 13 pp. Discusses the need for natural areas preservation, objectives, and criteria for evaluating potential preserves. The Commission has also issued (1973) a 65-page Two-Year Report, 1971-1972. (See notice of previous biennial report, Mich. Bot. 11: 78. March 1972.) Both publications are very well done and should be of great interest to members of the Michigan Natural Areas Council and others concerned wtih natural areas locally.

SEDIMENTOLOGY OF A BEACH BIDGE COMPLEX AND ITS SIGNIFICANCE IN LAND-USE PLANNING. By Norman C. Hester and Gordon S. Fraser. Illinois State Geol. Surv. Environ. Geol. Notes 63. 1973. 24 pp. Treats the geological basis of a beach ridge complex characterized by erosion and aggradation. The habitat is a widespread and interesting one around the Great Lakes, and the particular area studied (between Waukegan, Illinois, and Kenosha, Wisconsin) is exactly that covered by F. C. Gates in "The vegetation of the beach area in northeastern Illinois and southeastern Wisconsin" (Ill. St. Lab. Nat. Hist., 1912). Well illustrated with photographs, maps, profiles, and sediment data.

FOREST ECOLOGY. 2nd Ed. By Stephen H. Spurr and Burton V. Barnes. Ronald Press, New York. 1973. 571 pp. $12.50. "The book is devoted to providing an understanding of the basic ecological relationships of individual trees, forest communities, and forest ecosystems." A few of the illustrations or examples are from Michigan, but this text is mentioned here not so much because of these (resulting, perhaps, from the authors' intimate associations with the U. of M.) as because it is an excellent broad introduction to ecology and should be of value to many members of the Michigan Botanical Club who would like clear, relatively non-technical explanations of such matters as climate, site, soil, competition, succession, climax, and related topics.

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Vol. 13, No. 3

THE MICHIGAN BOTANIST

May, 1974

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Back issues beginning with Vol. 14 are $5.00 per volume ($1.25 per number). Complete sets and sets beginning with Vol. 2 are available. On these, as on any order totalling 20 or more copies, a 25% discount is allowed.

Subscriptions (from those not members of the Michigan Botanical Club) and all orders for back issues should be addressed to the business and circulation manager.

Address changes from Botanical Club members should be sent only to appropriate chapter officers. Address changes for *non-member subscribers only* should be sent to the business and circulation manager. Send *no* address changes to the editor.

Articles dealing with any phase of botany relating to the Upper Great Lakes Region may be sent to the editor in chief. In preparing manuscripts, authors are requested to follow our style and the suggestions in "Information for Authors" (Vol. 12, p. 142).

THE MICHIGAN BOTANICAL CLUB

Membership in the Michigan Botanical Club is open to anyone interested in its aims: conservation of all native plants; education of the public to appreciate and preserve plant life; sponsorship of research and publication on the plant life of the State; sponsorship of legislation to promote the preservation of Michigan native flora and to establish suitable sanctuaries and natural areas; and cooperation in programs concerned with the wise use and conservation of all natural resources and scenic features.

Dues are modest, but vary slightly among the chapters and with different classes of membership. Persons desiring to become state members (not affiliated with a local chapter, for which secretaries or other contact persons are listed below) may send $5.00 dues to the Membership Chairman listed below. In all cases, dues include subscription to THE MICHIGAN BOTANIST. (Persons and institutions desiring to subscribe without becoming members should deal with the business and circulation manager as stated at the top of this page.)

VEGETATION AND FLORA OF KEWEENAW COUNTY, MICHIGAN

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Cranbrook Institute of Science,
Bloomfield Hills, Michigan 48013

This is a brief account of the flora and various ecological communities of Keweenaw County, Michigan's northernmost county. Comprising the tip of the Keweenaw Peninsula, it is bounded on the north, west, and east by Lake Superior and has a land surface of approximately 538 square miles. It has a maximum length of 38 miles in an east-west orientation and a maximum width of 17 miles in a north-south direction. Keweenaw is Michigan's least populated county, the 1970 census showing 2264 residents, down 153 from the 1960 tabulation. This region received considerable attention during the past century due to the lumbering and copper mining opportunities it afforded.

The authors believe that in the near future the next principal expansion of activities in the peninsular region will be oriented towards tourism and recreation. These forthcoming changes are likely to have a profound and lasting affect upon the quantity and to a degree the quality of local native biota. In anticipation of future needs, it seemed timely to carry out a vegetational survey of this county to furnish basic data relating to the character of its natural vegetation.

Keweenaw County includes two principal islands of note: Isle Royale, which is some 48 miles northwest of Copper Harbor, and Manitou Island, located approximately three miles east of the peninsular tip. Our treatment excludes Isle Royale; a flora of this island was published elsewhere (Brown, 1937). We also omit a summary of Manitou Island vegetation, which is covered in a paper now in press (Thompson & Wells, 1974).

Keweenaw County has been ravaged by fires, mining, and poor lumbering practices. Consequently, only vestiges of the original forest cover types remain. Perhaps the choicest remnant of timber left is the 160-acre Estivant Pines preserve, which was established through the joint efforts of Goodman Lumber Company, a subsidiary of Universal Oil Products Company, and the Michigan Nature Association.

The vast influence of mining on the vegetation of this region is easily underestimated. Although several hundred mining projects were attempted, it was the success of relatively few that so greatly changed the aspect of this region. Well over a billion feet of lumber were used in mine construction (Murdoch, 1943). Inhabitants in villages near the mines numbered in the hundreds, whereas today few or no residents remain.

GEOLOGY

From observation points on Brockway Mountain Drive or from the tower on top of the cone-shaped peak of Mt. Bohemia one can observe the series of ancient mountain ridges that form the backbone of the Keweenaw Peninsula. Five parallel ridges extend northward from the south boundary of the county, curve to the northeast, and finally stretch out to the east along the tip of the peninsula, where they dip into the cold water of Lake Superior. The southernmost and most prominent of these parallel ridges is the one formed by the Keweenaw Fault. Then, in a northward progression, the succeeding ridges are Cliff Range (Allouez Conglomerate), the Great Conglomerate, the Middle Conglomerate, and finally, along the shores of Lake Superior, the Copper Harbor Conglomerate ridge. The resistant rock of the Copper Harbor Conglomerate forms the rocky barrier ridge that hems in Copper Harbor and Agate Harbor, whereas the Middle Conglomerate shapes Grand Marais, Eagle Harbor, and Cat Harbor. These dark reddish brown conglomerates are most conspicuous along the north shore of the county and along the sparsely vegetated portions of ridges such as Mt. Lookout, East Bluff, and West Bluff, which rise to 735 feet above the level of Lake Superior. These conglomerates dip into Lake Superior at a downward slope of often as much as 45° and form the picturesque rocky shoreline so characteristic of the northern border of the Keweenaw Peninsula. The conglomerates extend beneath Lake Superior and reappear some 48 miles off-shore in Isle Royale (Wolff & Huber, 1973). In places they are between 35,000 and 50,000 feet thick (Dorr & Eschman, 1970). Among the igneous rocks are basalt, traps, and gabbros whose origins were from many lava flows.

The highest elevation in the county, 1534 feet, is recorded for Mt. Horace Greeley, located northwest of Gratiot Lake, while Lake Superior elevation averages about 600 feet. Therefore, maximum land elevation is over 900 feet above the lake level.

The Keweenaw Fault ridge is imposing. In contrast, to the south and east of the fault ridge the land is low and flat and consists of a much younger rock formation, the Jacobsville Sandstone, which was laid down during the beginning of the Cambrian. North of the fault line the rocks are much older, dating back to the Keweenawan period when volcanic activity caused the formation of this series of conspicuous ridges. The Keweenawan series comprises some of the oldest formations in North America.

Fig. 1 is a geological map of the county with relative ages of strata. The Upper Huronian, about two billion years old, is the oldest and may be seen in four small areas in the eastern portion of the county. The Lower Cambrian, characterized by the Jacobsville Sandstone, is the most recent, being 600 million years old. The Jacobsville Sandstone lies upon the much older Keweenawan series, which is exposed north of the Keweenaw Fault. This fault is essentially a sharp discontinuity between the Lower Cambrian and the Keweenawan series. Northeastward the fault passes north of Lac La Belle and then into Lake Superior. Southwestward it continues into Houghton County as far as the Houghton-Hancock area. This break in the earth's crust was accompanied by an uplifting of the older Keweenawan rocks whereas the younger Jacobsville Sandstone rocks to the south downdropped (Dorr & Eschman, 1970). The fault may best be observed at close range near the

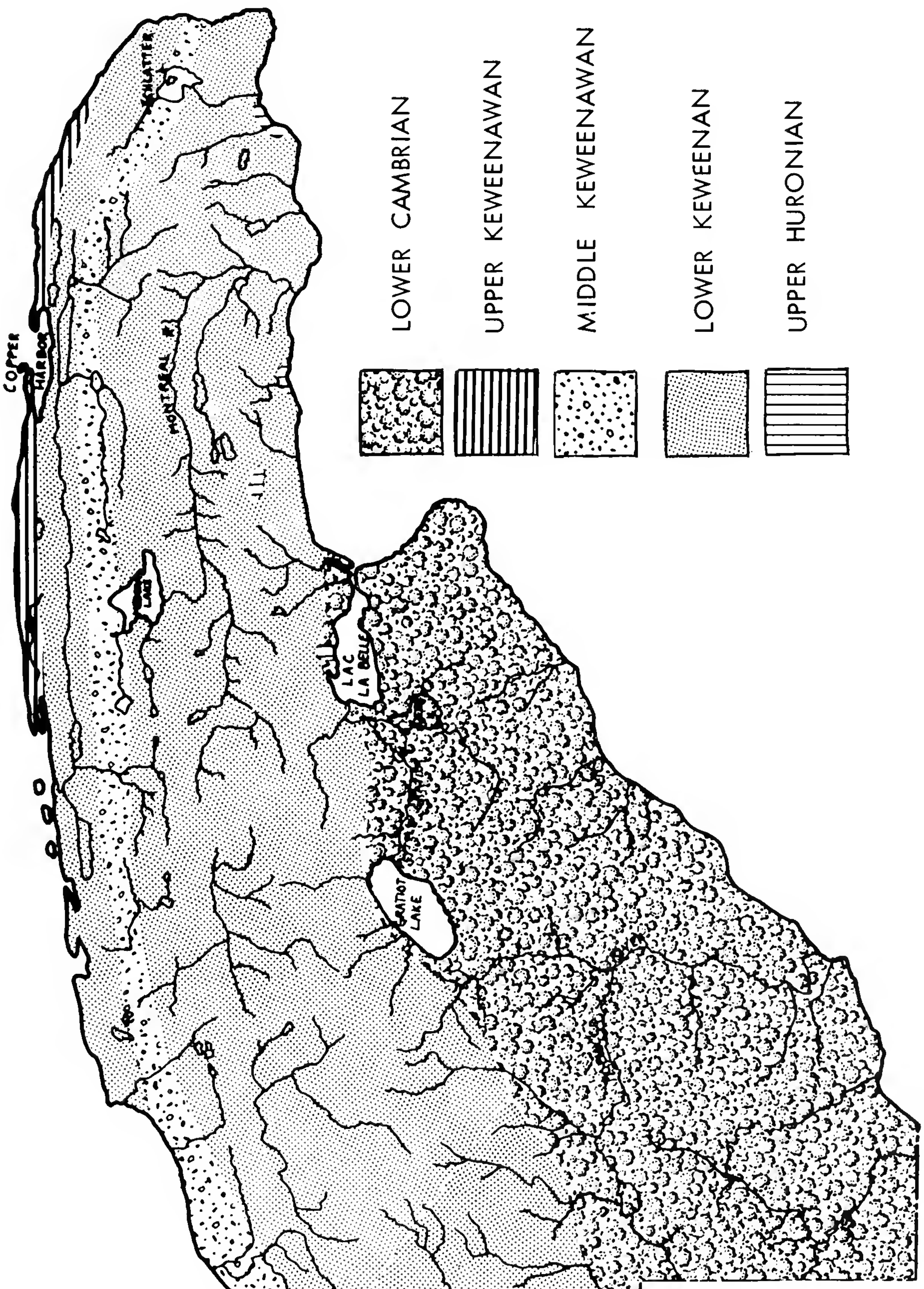


Fig. 1. Geological map of Keweenaw County, Michigan, showing relative ages of strata. Based on Helen M. Martin, Mich. Geol. Surv. Publ. 39 (Geol. Series 33), 1936.

scenic Douglass Houghton Falls located at Laurium in adjacent Houghton County.

The above series of ancient ranges has not only helped shape the peninsula, serving as its foundation, but has also played a prominent role in its history, economy, and vegetational pattern. The beautiful rugged scenery is a major local attraction. The ridges formed by the more resistant rock furnish vantage points from which one may observe the superb natural features of the area. Between these ranges the less resistant rock has eroded over the centuries and formed deep valleys covered with verdant forests. These valleys confine the rivers and streams to an east-west course until they reach an area where erosional forces have finally cut through the barrier ridges. Scenic waterfalls exist where streams pass over these resistant ridges. The confining character of these valleys has resulted in the creation of lakes, ponds, and harbors in these low areas in addition to numerous bogs and swamps. The principal harbors, such as Copper Harbor and Eagle Harbor, as well as certain lakes, including Lake Fanny Hooe and Lake Bailey, were formed by erosion of the softer sediments lying adjacent to the relatively more resistant Copper Harbor Conglomerate. These harbors offer some of the most scenic sites in the county and continue to be of importance as a refuge for watercraft. The valleys also determine the routes of many of the roadways of the peninsula.

Fig. 2 shows the principal surface features of Keweenaw County. The land has been available for colonization by plants and animals for approximately 12,000 years, but topographically it is not very different from its appearance following the retreat of Wisconsin ice. According to Black (1969) ice advanced across the Keweenaw Peninsula from east to west. Its center was the Keweenaw lobe which lay inland from the end of Keweenaw Bay. The ice left some striae on rocks just north of Lake Medora, located in the east central portion of the county, as well as a similar record just north of Lac La Belle.

Sand dunes up to 100 feet high may be seen at Great Sand Bay, located in the northwestern section of the county along Lake Superior. These are derived in part from glacial lake beaches. Other prehistoric evidence of higher lake levels exists in the southern portion of the county near Gay. Here occur many parallel ridges with altitudinal variations of several feet, but these ridges often support a different flora than do the adjoining shallow and somewhat wetter troughs. This set of ridges and troughs are most noticeable from aerial views, but may be observed at roadside near the county line south of Gay in section 33.

Of nearly 100 named lakes in Keweenaw county, Fig. 3 shows only the larger ones, as well as principal rivers and streams. The largest lake, Lake Gratiot, covers 1438 acres and has a maximum depth of 78 feet. The Montreal River and the Tobacco River are the principal flowing streams in the county.

Soils data for Keweenaw County are not yet available. According to Ivan F. Schneider of the Crop and Soil Sciences Department, Michigan State University (personal communication), necessary field work was done in 1951, but data have not been compiled in map form on a county-wide basis.

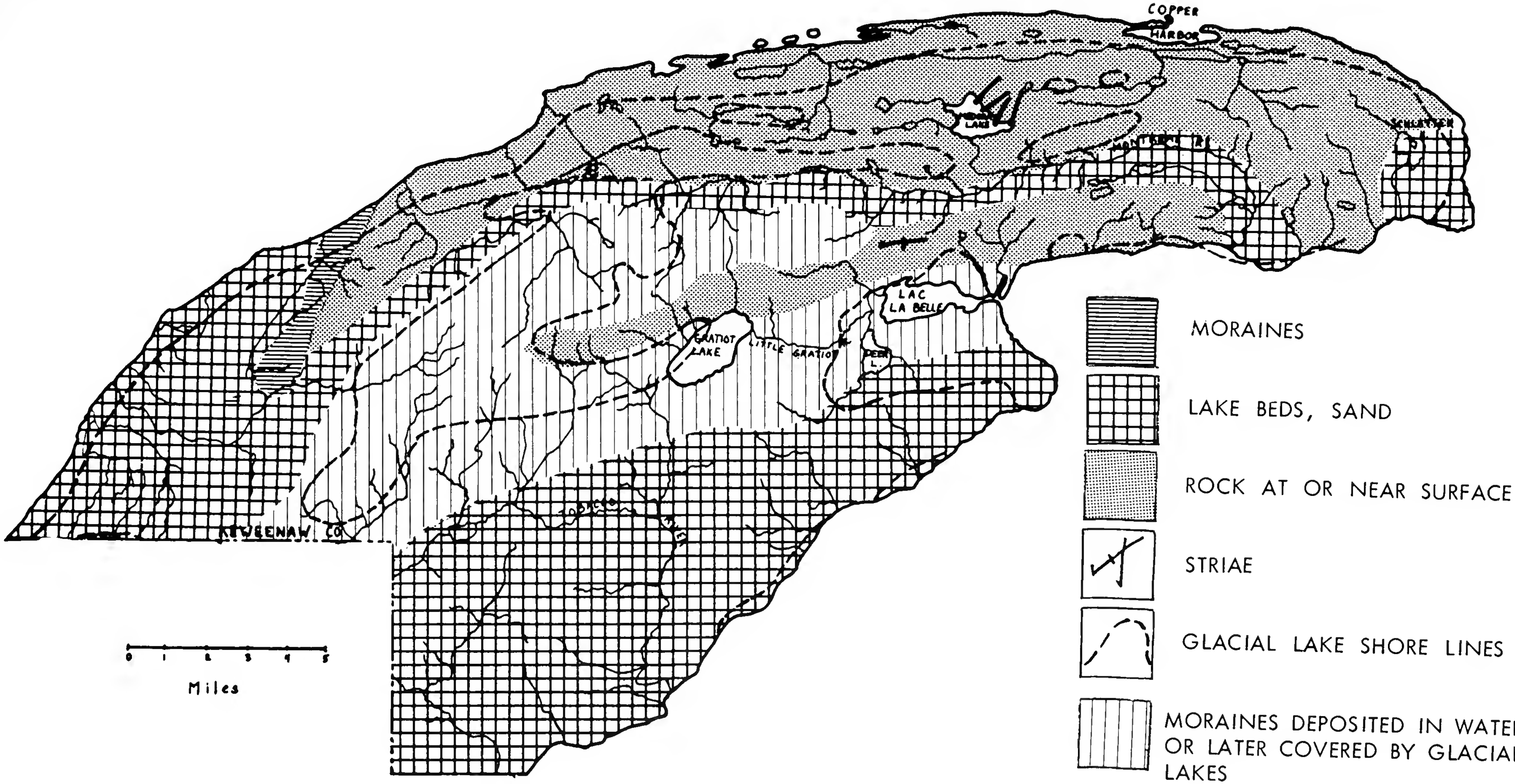


Fig. 2. Principal surface features of Keweenaw County, Michigan. Based on Helen M. Martin, Mich. Geol. Surv. Publ. 49, 1957.

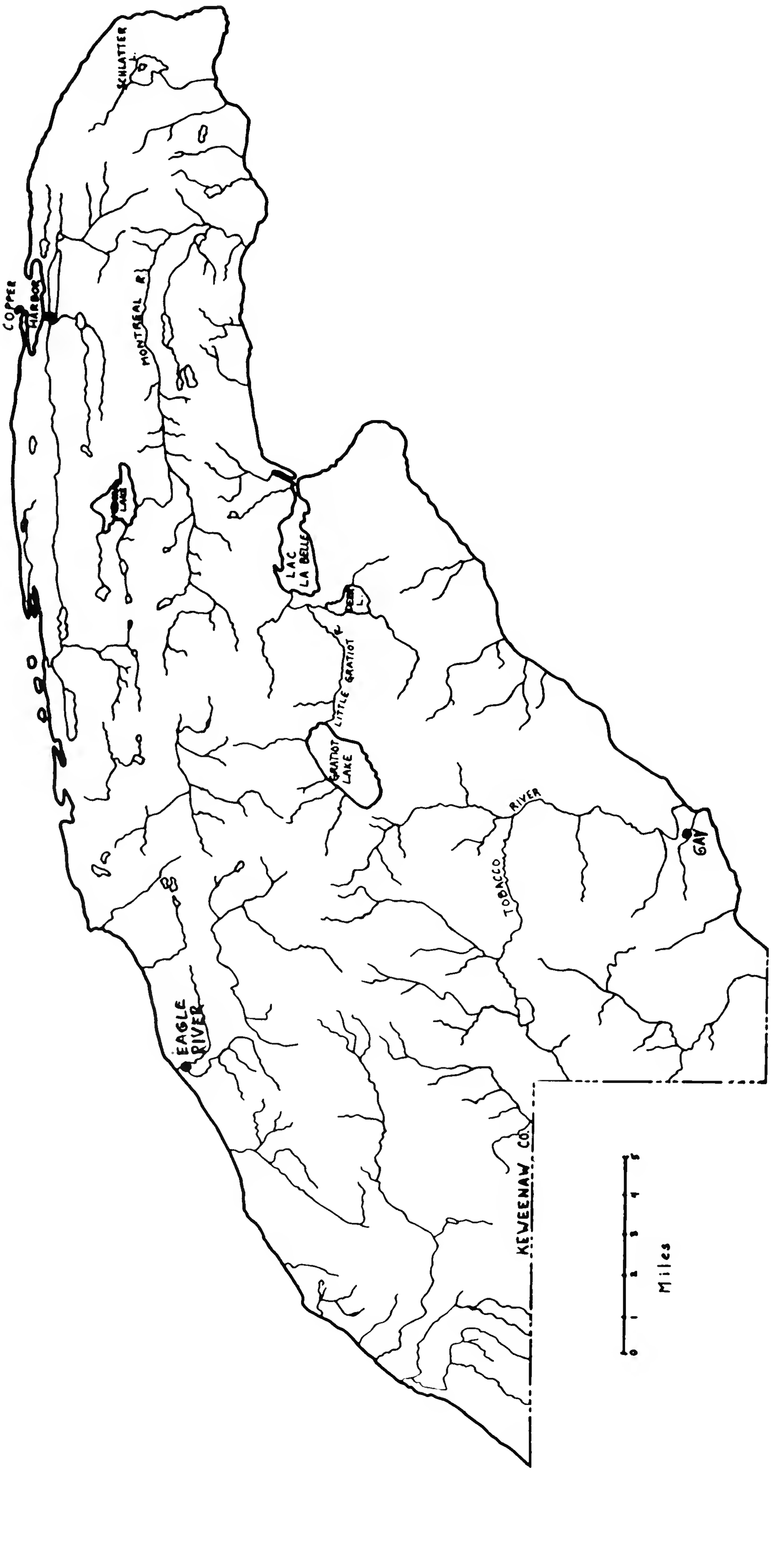


Fig. 3. Principal lakes and streams of Keweenaw County, Michigan. Copyright by AAA–reproduced by permission.

CLIMATE

In the Upper Peninsula the growing season may range from 60 to 90 days in the interior compared to 140-160 along the shores of the Great Lakes. Westerly cold fronts may be warmed by Lake Superior waters as much as 20° F. Alternatively, the cold winter temperatures once achieved persist longer into the spring due to the effects of the cold lake water. Thus, the spring season in the Copper Harbor region may arrive 10-15 days later than it does farther inland. The fall season correspondingly extends several weeks longer because of the ameliorating effects of the summer-warmed lake water.

The average date for the last spring frost at Eagle Harbor is May 20 and the average first fall frost is October 14. From 24 years of records taken at Eagle Harbor, the January average temperature is 16.8° F and the July average is 61.7°. Extremes for the period are 100° and −26° F. The average precipitation at the same location for a 29-year period was 29.11 inches/year. June through September precipitation averages about 3 inches/month, while the remaining months have from about 1.5 to 2.5 inches/month, January and February being the lowest.

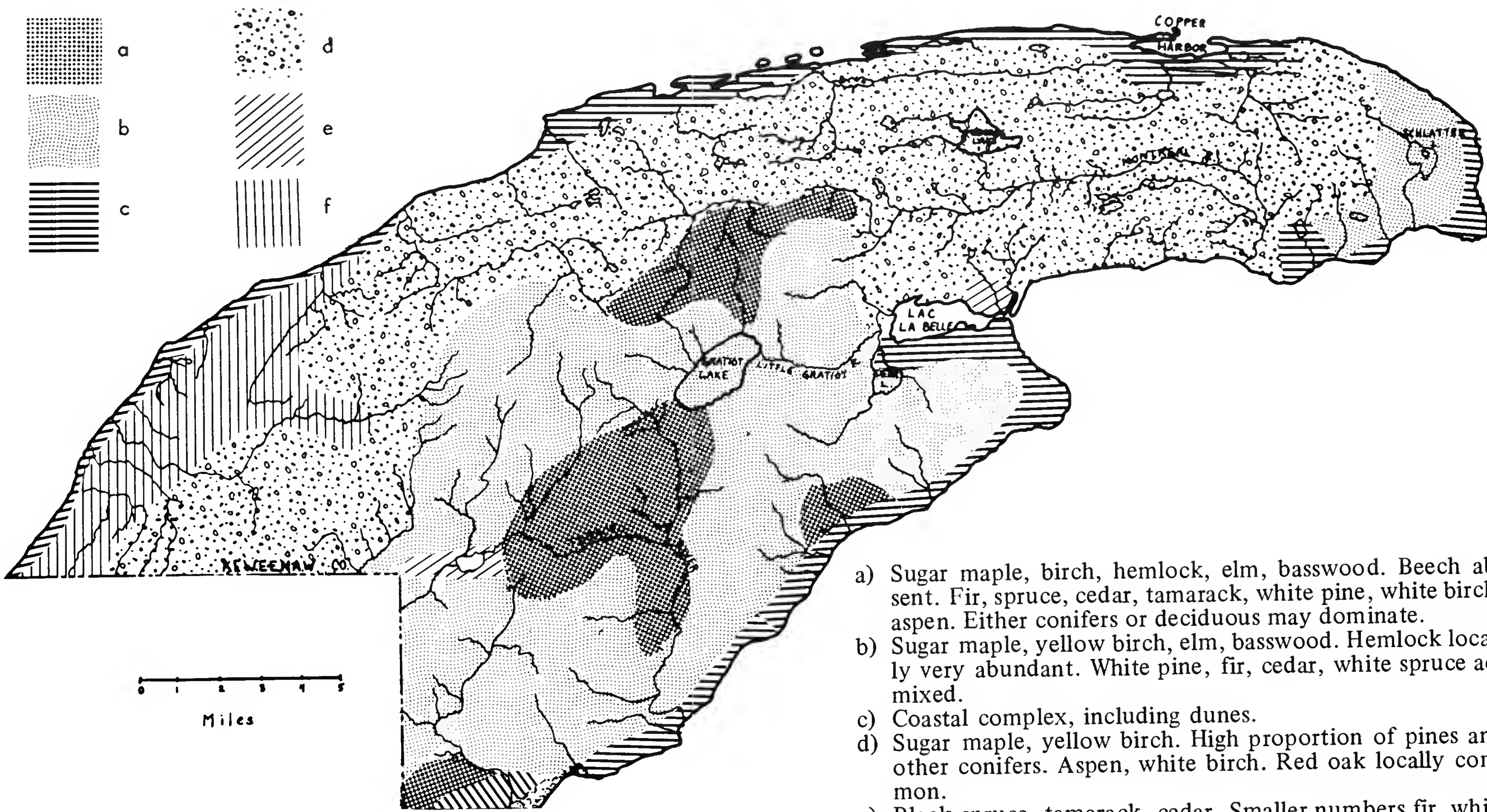
VEGETATION

Keweenaw County lies within the deciduous forest formation of eastern North America and, according to Braun (1950), the Superior Upland portion of the hemlock-white pine-northern hardwoods region. Although the region is characterized by alternation of coniferous, deciduous, and mixed forest communities, the predominance of coniferous species, particularly hemlock and white pine, has been greatly decreased due to the lumbering practices of the early settlers. Presettlement forest types are shown in Fig. 4.

Although a large proportion of the Keweenaw Peninsula is today covered by forest, most of it is in second-growth stands which lack the richness and diversity of mature tracts. Virgin forests were destroyed through mining and lumbering practices during the latter half of the nineteenth century. Vast areas were cut for fuel, and it is estimated that over a billion board feet of lumber lie underground in mine shafts. Following the mining period, many of the remaining woodlands were lumbered. Fortunately, the lumbering practices today are carried out with greater care than was the case in years past.

The second-growth woodlands that cover many of these denuded areas consist predominantly of sugar maple. The stands of trees are often very dense, and growth is especially slow where the bedrock is overlain with only a thin layer of soil. Other species occurring with maple are basswood, white birch, red maple, ironwood, and occasionally red oak. Yellow birch is a constitutent in low-lying areas. Ground-cover plants consist largely of spring-flowering species, but these occur in small numbers and the diversity is not great.

During the 1972 season an extensive survey was made of the types of plant communities found in Keweenaw County. Three one-week trips, covering different phases of the growing season, were made to the area to collect



a) Sugar maple, birch, hemlock, elm, basswood. Beech absent. Fir, spruce, cedar, tamarack, white pine, white birch, aspen. Either conifers or deciduous may dominate.
b) Sugar maple, yellow birch, elm, basswood. Hemlock locally very abundant. White pine, fir, cedar, white spruce admixed.
c) Coastal complex, including dunes.
d) Sugar maple, yellow birch. High proportion of pines and other conifers. Aspen, white birch. Red oak locally common.
e) Black spruce, tamarack, cedar. Smaller numbers fir, white pine. Variable aspen, white birch, willow, alder, red maple, black ash.
f) Sugar maple, yellow birch, hemlock, white pine. Beech absent. Increase in conifers.

Fig. 4. Presettlement forest types of Keweenaw County, Michigan. From J. O. Veatch, Mich. State Univ., 1959.

comprehensive data on these communities. Based on these data, characterizations of the principal plant habitats are given below. These include descriptions of hardwood and mixed forests, hemlock stands, boreal forests, and pine barrens. Other sections deal with the distinctive mountain ridgetop vegetation and the rocky shorelines so characteristic of this part of Lake Superior. Additional treatments cover dune habitats, bogs, aquatic and wetland vegetation of lakes and ponds, and field, meadow, and roadside communities.

HARDWOOD AND MIXED FORESTS

Because of extensive disturbance in the past, rich well-developed forests are relatively scarce in the Keweenaw. One of the largest undisturbed areas is the Estivant Pine tract, a portion of which is shown in Fig. 5. Representative of the potential forest development on areas possessing a deeper soil cover is a forested tract in a low area just south of the ridge on which the Hanover mine is located, close to the spot known as the Cathedral Pines.

Whereas this tract consists largely of mature sugar maples, the woodland is dominated by approximately three dozen large white pines scattered throughout the stand. Other tree species encountered are the white birch, balsam fir, and red maple. A giant red oak was found on the western edge of the tract. Much of the conspicuous ground cover consists of maple and balsam fir seedlings mixed with a few seedlings of red oak. One mountain-ash seedling was noted.

Common ground-cover plants in the Estivant tract are large-leaved aster (*Aster macrophyllus*) and Canada mayflower (*Maianthemum canadense*). Two species of orchids are fairly common, the bracted (*Habenaria viridis*) and the rattlesnake-plantain (*Goodyera oblongifolia*). Other species consist of twisted-stalk (*Streptopus roseus*), wild sarsaparilla (*Aralia nudicaulis*), clintonia (*Clintonia borealis*), strawberry (*Fragaria virginiana*), white baneberry (*Actaea alba*), roundleaved hepatica (*Hepatica americana*), nude mitrewort (*Mitella nuda*), sweet cicely (*Osmorhiza* spp.), violets (*Viola* spp.), prince's pine (*Chimaphila umbellata*), one-sided shinleaf (*Pyrola secunda*), elliptic shinleaf (*P. elliptica*), and one of the interesting disjuncts of the region, trail-plant (*Adenocaulon bicolor*). Ferns and their allies are represented by rattlesnake fern (*Botrychium virginianum*), bracken (*Pteridium aquilinum*), and the shining club-moss (*Lycopodium lucidulum*). Shrubs found in the tract consist of thimbleberry (*Rubus parviflorus*), twining honeysuckle (*Lonicera diocia*), and bilberry (*Vaccinium membranaceum*). In an adjoining lower area additional species of trees are black spruce, white-cedar, and mountain maple (*Acer spicatum*).

Although core samples from the Estivant Pine trees showed ages of the pines to be in the range of 150 years old, it should be emphasized that ring counts of other pines in adjoining areas exceeded 500 years!

Another mixed forest tract that until 1972 was relatively undisturbed is one located along the rugged terrain just northwest of Gratiot Lake in the vicinity of 932 Creek. This area shows the greatest diversity of species of any of the forest types examined in Keweenaw County. Represented here are sugar maple, red maple, basswood, white pine, white spruce, white ash, white birch, yellow birch, American elm, red oak, balsam fir, white-cedar, hemlock, mountain-ash (*Sorbus decora*), ironwood (*Ostrya virginiana*), shadbush, and mountain maple. In addition to the ground-cover species mentioned in the preceeding tract are also smooth yellow violet (*Viola eriocarpa*), star-flower (*Trientalis borealis*), false Solomon's seal (*Smilacina racemosa*), jack-in-the-pulpit (*Arisaema triphyllum*), common speedwell (*Veronica officinalis*), squaw-root (*Conopholis americana*), interrupted fern (*Osmunda claytoniana*), drooping wood sedge (*Carex arctata*), and a very common springtime species, yellow trout-lily (*Erythronium americanum*). Several interesting ferns reflect the cool moist atmosphere of the steep-sided ravine: Braun's holly fern (*Polystichum braunii*), northern holly fern (*P. lonchitis*), oak fern (*Gymnocarpium dryopteris*), polypody (*Polypodium vulgare*), and the broad beech fern (*Thelypteris hexagonoptera*). Additional plant species are nodding trillium (*Trillium cernuum*), smooth white violet (*Viola pallens*), marsh blue violet (*V. cucullata*), wild iris (*Iris versicolor*), red-berried elder (*Sambucus pubens*), goldthread (*Coptis trifolia*), bunchberry (*Cornus canadensis*), and trailing arbutus (*Epigaea repens*).

Indicative of the size of some of the large trees of the tract are the following (girth given in inches at breast height):

white pine 132, 113, 101, 86, 81	white-cedar 112, 79, 75
white spruce 57	American elm 126
balsam fir 49	sugar maple 77
hemlock 100, 85, 69, 46	yellow birch 129, 117, 107, 81

A tract characteristic of an excellent mixed forest is one just south of the Montreal River directly east of the point where the Mandan Road crosses the river. Large trees are found in this area as shown by the following (girth given in inches at breast height):

white birch 94	white spruce 57, 56
yellow birch 128, 106, 100	balsam fir 54
sugar maple 80	white-cedar 89
red maple 61	mountain-ash 27

HEMLOCK STANDS

Still remaining in the Huron Mountains region and in the Porcupine Mountains are extensive pure stands of hemlock. In Keweenaw County it was only after we had completed considerable survey work that any hemlock stands were observed. That the region can support hemlock is borne out by original survey records of Samuel W. Hill and others made between June 25, 1844 and February 4, 1846. Their records are deposited in the courthouse at Eagle River and contain many references to hemlock, including one of 88 inches circumference. (Incidentally, it was this surveyor whose name was immortalized by the expression: "What in Sam Hill. . . !")

On the basis of these survey records, the frequency with which hemlocks were mentioned indicate that two areas—both located along the very

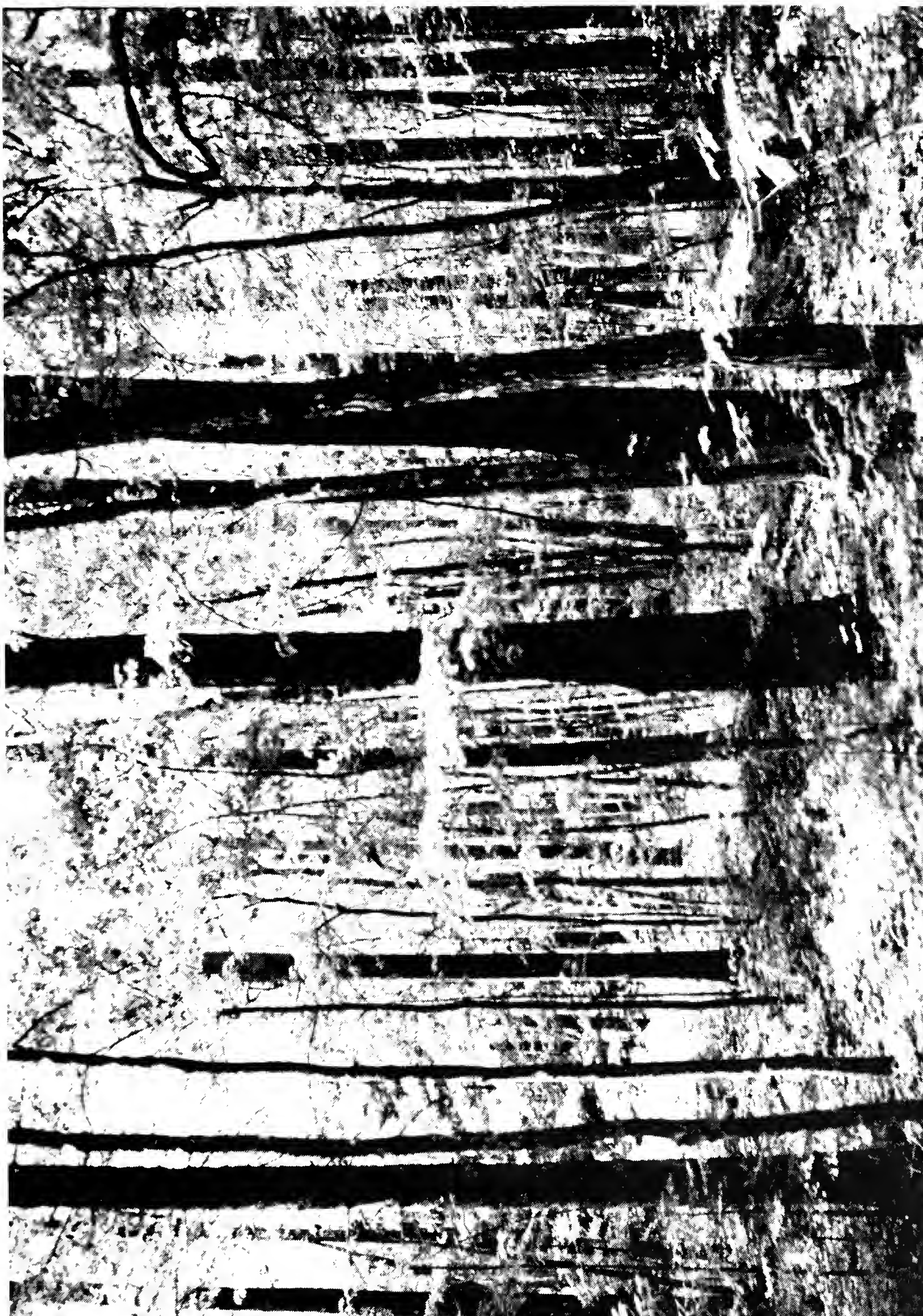


Fig. 5. Forest cover at Estivant Pines area near Hanover Mine, Keweenaw County, Michigan, June 14, 1972.

rugged Keweenaw Fault Ridge—contained considerable hemlock. One of these was located in the sector north and west of Lake Gratiot. A more extensive check of this locality revealed a number of large hemlocks occurring in mixed stands, but no pure stands were observed. The second tract occupied a large area north and west of Lac La Belle. Data suggested that this section should contain considerable hemlock. Although the entire locality was not surveyed, no hemlock was observed in the areas which were examined, indicating that this species may have been removed by lumbering.

A third sector which initially contained hemlock was the low, relatively flat ground in the southern portion of the county west and north of Gay. A small stand of hemlock was located along the south side of the Mohawk-Gay road approximately 2.5 miles from Gay in a forested area. Hemlocks with girths of 55, 54, 46, 45, 42, and 34 inches were noted. Other species in the vicinity showed girth measurements as follows: white pine, 63; sugar maple, 104, 89, 86; red maple, 107, 82, 81; white spruce, 45, 45, 42; balsam fir, 51, 50, 44; and yellow birch, 102, 102, 94.

The best locality for hemlock was found, at the recommendation of a local forester, in section 7, T56N, R31W, about 1.5 miles southwest of Thayer's Lake. The area could be essentially characterized as a low mixed swampy flat in which birch predominates. However, small flat knolls scattered throughout the area contain small stands of hemlock. Girth measurements in inches for the largest were 74, 57, 54, 49, 48, 48, 45, 44, 42, 41, 41. Herbaceous plants in the area are Canada mayflower (*Maianthemum canadense*), star-flower (*Trientalis borealis*), clintonia (*Clintonia borealis*), wild sarsaparilla (*Aralia nudicaulis*), bunchberry (*Cornus canadensis*), twisted-stalk (*Streptopus roseus*), false Solomon's seal (*Smilacina racemosa*), bilberry (*Vaccinium membranaceum*), Indian pipe (*Monotropa uniflora*), and rattle-snake-plantian (*Goodyera oblongifolia*). Other species are bristly club-moss (*Lycopodium annotinum*), spinulose shield-fern (*Dryopteris spinulosa*), and Canada honeysuckle (*Lonicera canadensis*). Trees in the surrounding areas are yellow birch, white spruce, balsam fir, white pine, mountain maple, and mountain-ash.

BOREAL FOREST

The boreal forest is the typical vegetation covering a large portion of Canada north of the Great Lakes region. These characteristic woodlands occur south of this formation where cool, humid atmospheric conditions exist locally. In the Keweenaw this type of forest is found on the flats near Lake Superior, especially in areas adjoining streams or other bodies of water. In such situations the moisture-laden winds of Lake Superior produce a local cooling effect that results in a high precipitation-evaporation ratio.

The predominant trees in this type of community are balsam fir (*Abies balsamea*) mixed with abundant white-cedar (*Thuja occidentalis*); white spruce (*Picea glauca*) may also be present. Other common species are white birch (*Betula papyrifera*), mountain-ash (*Sorbus decora*), and occasionally yellow birch (*Betula alleghaniensis*). A very common understory tree in these cool situations is mountain maple (*Acer spicatum*). Woody species consist of Canada honeysuckle (*Lonicera canadensis*), red-berried elder (*Sambucus pubens*), highbush-cranberry (*Viburnum opulus*), and speckled alder (*Alnus rugosa*). Ground species especially adapted to this type of habitat are the mountain sorrel (*Oxalis acetosella*), northern bluebell (*Mertensia paniculata*), alpine enchanter's nightshade (*Circaea alpina*), wild comfrey (*Cynoglossum boreale*), clintonia (*Clintonia borealis*), nude mitrewort (*Mitella nuda*), twisted-stalk (*Streptopus roseus*), trail-plant (*Adenocaulon bicolor*), star-flower (*Trientalis borealis*), and several species of violets (*Viola* spp.).

Inhabiting the cooler, moist areas are a number of fern species: bulblet fern (*Cystopteris bulbifera*), sensitive fern (*Onoclea sensibilis*), ostrich fern (*Matteuccia struthiopteris*), spinulose shield-fern (*Dryopteris spinulosa*), northern beech-fern (*Thelypteris phegopteris*), oak-fern (*Gymnocarpium dryopteris*), and occasionally Braun's holly fern (*Polystichum braunii*). Other species often found in these communities are wild sarsaparilla (*Aralia nudicaulis*), Canada mayflower (*Maianthemum canadense*), bunchberry (*Cornus canadensis*), large-leaved aster (*Aster macrophyllus*), calico aster (*Aster lateriflorus*), purple meadow-rue (*Thalictrum dasycarpum*), and sweet-scented bedstraw (*Galium triflorum*).

Some areas where boreal forests are found include the border of Lake Superior east of Copper Harbor, along the tip of the peninsula, adjoining Bête Grise Bay, and in the low, moist areas between Copper Harbor and Eagle River.

PINE BARRENS

This type of vegetation is often termed pine plains or, where jack pine predominates, jack pine plains, as the terrain is usually quite flat. The soil is normally shallow and of poor quality, and in the Keweenaw commonly mixed with rocks and stones. Often it borders the coastline of Lake Superior. In such situations, the ground is covered with mosses and reindeer lichen and tree species are commonly draped with hanging lichens, indicating the higher moisture content of the cool atmosphere close to the lake. The principal tree species consist of white, red, and sometimes jack pine (*Pinus strobus, P. resinosa,* and *P. banksiana*). Trees are widely spaced, however, producing an open savannah type of plant community.

An excellent example of this kind of vegetation occurs at Lighthouse Point near Copper Harbor. Other occasional tree species are white birch (*Betula papyrifera*), white spruce (*Picea glauca*), red maple (*Acer rubrum*), mountain-ash (*Sorbus* spp.), and shadbush (*Amelanchier* spp.). Common shrubs are buffalo berry (*Shepherdia canadensis*), low juniper (*Juniperus communis* var. *depressa*), and bush-honeysuckle (*Diervilla lonicera*). Common plants growing in the ground cover are bearberry (*Arctostaphylos uva-ursi*), Canada mayflower (*Maianthemum canadense*), largeleaf aster (*Aster macrophyllus*), strawberry (*Fragaria virginiana*), false toadflax (*Comandra richardsiana*), barren strawberry (*Waldsteinia fragarioides*), and cow-wheat (*Melampyrum lineare*). Other conspicuous species are fringed polygala

(*Polygala paucifolia*), harebell (*Campanula rotundifolia*), a largespur violet (*Viola adunca*), pink corydalis (*Corydalis sempervirens*), hairy goldenrod (*Solidago hispida*), and prickly rose (*Rosa acicularis*).

Other species which occur occasionally in this type of habitat are trailing arbutus (*Epigaea repens*), pink lady-slipper (*Cypripedium acaule*), wintergreen (*Gaultheria procumbens*), low blueberry (*Vaccinium angustifolium*), bracken (*Pteridium aquilinum*), and red oak (*Quercus borealis*). Similar pine-barren stands are found along the lake front in the vicinity of Hebard Park and in dry sandy areas along Keweenaw Bay.

MOUNTAIN RIDGETOPS

The higher points of the mountain ridges of the Keweenaw often exhibit unusual vegetational patterns. Such areas are exposed to the full force of strong, sweeping winds which are often colder than those of surrounding locations and normally contain moisture collected from the passage over lake waters. As a result of these rugged conditions trees, shrubs, and herbs are considerably reduced in size. Exposed locations, semi-alpine in nature, are essentially "treeless" as the trees are reduced to the size of shrubs. These exposed ridges offer excellent hiking trails and, because of their unusual elevations, are wonderful scenic sites. Beautiful panoramic views of the natural scenery of the Keweenaw Peninsula can be obtained from these vantage points.

The ridgetop of Mount Lookout is an excellent example of this type of habitat. Dwarf trees of balsam fir, white-cedar, white pine, white spruce, quaking aspen, red maple, and red oak, often less than 10 feet in height, are widely scattered. Vegetational clumping is common; often several trees and shrubs grow in close proximity resulting in mutual protection. Low juniper (*Juniperus communis* var. *depressa*), shadbush (*Amelanchier* spp.), hawthorn (*Crataegus* spp.), thimbleberry (*Rubus parviflorus*), buffalo berry (*Shepherdia canadensis*), and snowberry (*Symphoricarpus albus*) are some of the dwarfed shrubs clustering about the spots covered by tree clumps.

In the broad open spaces between clumps the ground is often carpeted by a ground-cover of small plants only a few inches in height. Common in such coverings are bearberry (*Arctostaphylos uva-ursi*), horizontal juniper (*Juniperus horizontalis*), three-toothed cinquefoil (*Potentilla tridentata*), and strawberry (*Fragaria virginiana*). Scattered throughout this protective cover and scarcely protruding from its canopy are Rand's goldenrod (*Solidago spathulata* ssp. *randii*), showy goldenrod (*S. speciosa*), large-leaved aster (*Aster macrophyllus*), Canada hawkweed (*Hieracium canadense*), Canada mayflower (*Maianthemum canadense*), harebell (*Campanula rotundifolia*), and prickly rose (*Rosa acicularis*). Other species found occasionally in this cover are beach wormwood (*Artemisia caudata*), low blueberry (*Vaccinium angustifolium*), velvet-leaved blueberry (*V. myrtilloides*), American vetch (*Vicia americana*), pale vetchling (*Lathyrus ochroleucus*), poverty grass (*Danthonia spicata*), Canada bluegrass (*Poa compressa*), common hairgrass (*Deschampsia flexuosa*), rusty woodsia (*Woodsia ilvensis*), false toadflax (*Comandra richardsiana*), narrow-leaved fleabane (*Erigeron strigosus*), Douglas knotweed (*Polygonum douglasii*), and rock spike-moss (*Selaginella rupestris*).

BOGS

Boggy vegetation is typical of low wet areas of the Keweenaw. The dominant trees are often white-cedar (*Thuja occidentalis*) mixed with black spruce (*Picea mariana*), which gives such areas a muskeg aspect with trees well spaced. Much of the area is quite wet with hummocks of sphagnum or other hydric mosses. In the more open, wetter spots speckled alder (*Alnus rugosa*) or tamarack (*Larix laricina*) grow, whereas the better-drained locations may be occupied by balsam fir (*Abies balsamea*).

The well-known bog at Cat Harbor typifies this type of vegetation. Here the dominant shrubs include labrador-tea (*Ledum groenlandicum*), leatherleaf (*Chamaedaphne calyculata*), bog-rosemary (*Andromeda glaucophylla*), and swamp laurel (*Kalmia polifolia*). Cottongrass (*Eriophorum* spp.) and other sedges predominate. Hummocks often are covered with creeping snowberry (*Gaultheria hispidula*), goldthread (*Coptis trifolia*), pitcher plants (*Sarracenia purpurea*), or the insectivorous roundleaf sundew (*Drosera rotundifolia*). Canada mayflower (*Maianthemum canadense*), dwarf raspberry (*Rubus pubescens*), bunchberry (*Cornus canadensis*), and star-flower (*Trientalis borealis*) are common. In wet situations one finds bog buckbean (*Menyanthes trifoliata*), three-leaved Solomon's seal (*Smilacina trifolia*), and marsh arrow-grass (*Triglochin palustre*). Showy plants of the area are marsh-marigold (*Caltha palustris*), the bright-colored fringed polygala (*Polygala paucifolia*), wild iris (*Iris versicolor*), blue bog violet (*Viola cucullata*), and the yellow-flowered bluebead-lily (*Clintonia borealis*). Occasionally one locates early coral-root orchid (*Corallorhiza trifida*), yellow lady-slipper (*Cypripedium calceolus*), showy lady-slipper (*C. reginae*), tall northern bog orchid (*Habenaria hyperborea*), bog candle (*H. dilatata*), heartleaved twayblade (*Listera cordata*), grass-pink orchid (*Calopogon tuberosus*), and rose pogonia (*Pogonia ophioglossoides*). Similar bogs are located at Eagle Harbor, Five Mile Point, and many other low locations throughout the peninsula.

ROCKY SHORELINES

One of the most distinctive areas of Keweenaw County is the rocky shoreline along Lake Superior. Huge masses of bare rock often line the water's edge. Although plants find few optimal niches in such locations, a surprising number of species occupy available niches in the conglomerate rock. Horseshoe Harbor typifies this kind of plant community. Common plants in the area are harebell (*Campanula rotundifolia*), bearberry (*Arctostaphylos uva-ursi*), beach pea (*Lathyrus maritimus*), strawberry (*Fragaria virginiana*), beach wormwood (*Artemisia caudata*), dwarf raspberry (*Rubus pubescens*), poverty grass (*Danthonia spicata*), and three-toothed cinquefoil (*Potentilla tridentata*). More showy species consist of tall cinquefoil (*Potentilla arguta*), Rand's goldenrod (*Solidago spathulata* ssp. *randii*), Canada hawkweed (*Hieracium canadense*), and prickly rose (*Rosa acicularis*). Conspicuous among the rocks in spring is bird's-eye primrose (*Primula mistassinica*), and later the northern bog violet (*Viola nephrophylla*) and distinctive white paintbrush (*Castilleja septentrionalis*).

As shrubby species, one finds buffalo berry (*Shepherdia canadensis*), low blueberry (*Vaccinium angustifolium*), sweet gale (*Myrica gale*), low juniper (*Juniperus communis*), bush-honeysuckle (*Diervilla lonicera*), and thimbleberry (*Rubus parviflorus*).

Occasionally dwarf specimens of white-cedar, white spruce, balsam fir, shadbush, and white birch are encountered. Two species which thrive in the cool moist atmosphere along the lake front are green alder (*Alnus crispa*) and mountain ash (*Sorbus decora*).

Habitats of a similar nature occur at the tip of the Keweenaw, Devil's Wash Tub, near Esrey Park, Agate Harbor, and Grand Marais.

DUNE FLORA

A long sweeping stretch of yellow sand marks the shoreline of Keweenaw Bay at Bête Grise. Here one finds dune flora typical of northern Michigan. Large patches of beach grass (*Ammophila breviligulata*) border the end of the open sand where this grass has retarded extensive sand movement. Beyond this protective barrier are beach pea (*Lathyrus maritimus*), beach wormwood (*Artemisia caudata*), lyre-leaved mustard (*Arabis lyrata*), evening-primrose (*Oenothera* sp.), and sand cherry (*Prunus pumila*). On the low dunes and swales just beyond this border, additional species that occur are false heather (*Hudsonia tomentosa*), low blueberry (*Vaccinium angustifolium*), false toadflax (*Comandra richardsiana*), bearberry (*Arctostaphylos uva-ursi*), strawberry (*Fragaria virginiana*), sweet vernal grass (*Anthoxanthum odoratum*), Pennsylvania sedge (*Carex pensylvanica*), and reindeer lichen (*Cladonia* spp.). Farther inland a few scattered red, white, and jack pines appear as the vegetation blends into pine plain stands.

Great Sand Bay is another area exhibiting dune flora, but here the sand washed up on the shore has been piled up into spectacular 100-foot-high sandhills. Additional species found here are Canada hawkweed (*Hieracium canadense*), yellow hawkweed (*H. florentinum*), white sweet clover (*Melilotus alba*), jointweed (*Polygonella articulata*), and Deam's goldenrod (*Solidago spathulata* ssp. *gillmanii*).

AQUATIC AND WETLAND VEGETATION OF LAKES AND PONDS

An excellent example of aquatic and wetland vegetation is found at Lac La Belle, especially the eastern section of the lake where extensive areas of shallower water exist. Submerged vegetation consists of a number of pondweeds, such as *Potamogeton natans, P. richardsonii, P. robbinsii, P. spirillus, P. zosteriformis,* and *P. gramineus*. Other species are yellow pond-lily (*Nuphar variegatum*), bushy pondweed (*Najas flexilis*), wild-celery (*Vallisneria americana*), waterweed (*Elodea canadensis*), water clubrush (*Scirpus subterminalis*), common bladderwort (*Utricularia vulgaris*), mare's tail (*Hippuris vulgaris*), and water milfoils (*Myriophyllum verticillatum* and *M. alterni-*

florum). Emergent species include the bulrushes (*Scirpus americanus, S. acutus,* and *S. validus*), arrowhead (*Sagittaria latifolia*), marsh cinquefoil (*Potentilla palustris*), broadleaf cat-tail (*Typha latifolia*), floating bur-reed (*Sparganium fluctuans*), wild iris (*Iris versicolor*), water sedge (*Carex aquatilis*), three-way sedge (*D. arundinaceum*), and rough cottongrass (*Eriophorum tenellum*). Sedges, spike-rushes, and rushes common along the shoreline include *Carex crinita, C. lasiocarpa, C. cephalantha, C. michauxiana, C. rostrata, C. oligosperma, C. viridula, Juncus effusus, J. tenuis, J. nodosus, J. dudleyi, Eleocharis elliptica, E. erythropoda, E. smallii, Scirpus atrovirens,* and *S. cyperinus.*

Other lakes displaying aquatic communities are Lake Manganese, Lake Medora—particularly the western bay, Thayer's Lake, Lake Fannie Hooe, and Seneca Lake. Deer Lake, which exhibits many aquatic species, contains a large colony of water shield (*Brasenia schreberi*) which covers several acres. Other aquatic species not listed above include *Potamogeton amplifolius, P. epihydrus, P. alpinus,* and *P. praelongus,* fragrant water lily (*Nymphaea odorata*), water-marigold (*Bidens beckii*), duckweed (*Lemna minor*), two species of white water-crowfoot (*Ranunculus aquatilis* and *R. circinatus*), and water smartweed (*Polygonum natans*). Additional sedge species are *Carex stricta, C. vesicaria, C. vulpinoidea, C. retrorsa, C. hystericina, C. viridula, C. pseudo-cyperus,* and *C. lanuginosa.*

Wetland species occurring near the shore include silverweed (*Potentilla anserina*), northern willow-herb (*Epilobium adenocaulon*), swamp rose (*Rosa palustris*), blue-joint grass (*Calamagrostis canadensis*), rice cut grass (*Leersia oryzoides*), monkey flower (*Mimulus ringens*), tufted loosestrife (*Naumburgia thyrsiflora*), marsh skullcap (*Scutellaria galericulata*), cutleaf water horehound (*Lycopus americanus*), northern bugleweed (*L. uniflorus*), corn mint (*Mentha arvensis*), marsh fern (*Thelypteris palustris*), swamp goldenrod (*Solidago uliginosa*), swamp candle (*Lysimachia terrestris*), turtlehead (*Chelone glabra*), purple meadow-rue (*Thalictrum dasycarpum*), marsh St. John's-wort (*Triadenum fraseri*), and northern St. John's-wort (*Hypericum boreale*). In many areas a solid fringe of sweet gale (*Myrica gale*) borders the water's edge. In other spots this species is mixed with speckled alder (*Alnus rugosa*), leatherleaf (*Chamaedaphne calyculata*), red osier dogwood (*Cornus stolonifera*), Michigan holly (*Ilex verticillata*), mountain holly (*Nemopanthus mucronatus*), and red maple (*Acer rubrum*).

PLANTS OF FIELDS, MEADOWS, AND ROADSIDES

Plants occupying these habitats thrive in strong sunlight. A number of these species, many of which are not native, frequently occur in large colonies presenting a color display. These include tall buttercup (*Ranunculus acris*), tawny hawkweed (*Hieracium aurantiacum*), yellow hawkweed (*H. florentinum*), ox-eye daisy (*Chrysanthemum leucanthemum*), common St. John's-wort (*Hypericum perforatum*), Joe-pye weed (*Eupatorium maculatum*), wild carrot (*Daucus carota*), wild bergamot (*Monarda fistulosa*), yellow rocket (*Barbarea vulgaris*), fireweed (*Epilobium angustifolium*), and common milkweed (*Ascelepias syriaca*). Other common species are dandelion (*Taraxacum officinale*), bladder campion (*Silene cucubalus*), white campion (*Lychnis alba*), pale cinquefoil (*Potentilla recta*), brown-eyed susan (*Rudbeckia hirta*), tickle-grass (*Agrostis hyemalis*), Canada bluegrass (*Poa compressa*), Kentucky blue-grass (*Poa pratensis*), red clover (*Trifolium pratense*), bouncing bet (*Saponaria officinalis*), and smooth sow-thistle (*Sonchus uliginosus*). Common along roadsides are such species as bracken (*Pteridium aquilinum*), common mullein (*Verbascum thapsus*), white sweet clover (*Melilotus alba*), and large-leaved aster (*Aster macrophyllus*). In low situations large colonies of Canada, tall, and giant goldenrod (*Solidago canadensis, S. altissima,* and *S. gigantea*) are often conspicuous. Less conspicuous in the above areas because of their size and color are yarrow (*Achillea millefolium*), winged cudweed (*Gnaphalium macounii*), pearly everlasting (*Anaphalis margaritacea*), pussy-toes (*Antennaria plantaginifolia* and *A. neglecta*), and strawberry (*Fragaria virginiana*). Scattered colorful species of these habitats include yellow avens (*Geum aleppicum*), wild basil (*Satureja vulgaris*), spreading dogbane (*Apocynum androsaemifolium*), and Canada hawkweed (*Hieracium canadense*).

FLORA

A checklist of vascular plants of Keweenaw County, Michigan, appears below. The nomenclature used is principally that of Gleason's *New Britton and Brown Illustrated Flora* (1952), except for the gymnosperms and monocots, which follow Voss's recent *Michigan Flora Part I* (1972). The list is based on specimens collected by the writers during the summer of 1972, now incorporated into the Billington Herbarium at Cranbrook Institute of Science. A critical examination was also made of the extensive collections at the University of Michigan Herbarium and at the Billington Herbarium, and all species from Keweenaw County found there were included in the checklist. Several of Farwell's records are open to question.

This survey revealed specimens collected from Keweenaw County by a number of noted botanists. The earliest known were made by Douglass Houghton, state geologist, who in 1831 and 1832 collected at "Keweenaw Point" (Rittenhouse & Voss, 1962). He could have been referring to the tip of the Keweenaw Peninsula, which 29 years later was to become part of the newly-formed Keweenaw County. Lewis Foote collected May 30-June 16, 1865, between Eagle River and Gratiot River, easily within the present county boundaries. Miss Mary H. Clark reportedly made collections at Copper Harbor on August 30, 1871, although very few of her collections are known to exist.

The most notable exponent of the flora of Keweenaw County was Oliver Atkins Farwell (1867-1944). According to his sister, Olive (personal communication), he had little formal botanical training but his greatest interest throughout his life was field botany. Certain of his other attributes were recently recounted by her (Wells & Thompson, 1973). Oliver's father was employed by and eventually owned controlling interest in Cliff Mine, and it was at this childhood residence, Clifton, where his earliest botanical interests were aroused through the inspired teaching of Mr. F. E. Wood. Farwell retired in 1933 and moved to Lake Linden (Houghton County), where he lived at the old family residence on Front Street. This house served as a base of operations for additional work on the peninsular flora until his death in 1944. His earliest known collections from Keweenaw County were made in 1883 at age 16, the same year that we noted the earliest collections by his teacher, Mr. Wood.

Other collectors who have worked in the county include M. L. Fernald and A. S. Pease, 1934; A. S. Pease and E. C. Ogden, 1935; F. J. Hermann, 1926, 1927, 1936, 1951; M. T. Bingham, 1942; R. McVaugh, 1947, 1948, 1949; C. D. Richards, 1948, 1949, 1950, 1951, 1956; D. J. Hagenah, 1952, 1953, 1964; D. J. Hagenah, J. R. Wells, and J. C. Filkins, 1970; F. K. Sparrow, 1962; E. G. Voss, 1958, 1965; and J. R. Wells and P. W. Thompson, 1972. The field work by Richards provided the basis for his 1952 dissertation, which contains substantial material relating to the vegetation of Keweenaw County.

RARE AND UNUSUAL PLANTS IN KEWEENAW COUNTY

The Keweenaw Peninsula has long been known for its impressive collection of disjuncts, species of plants that are widely separated from the principal range of distribution. Fernald (1935), in writing about these disjuncts, states: "It is significant, then, that Keweenaw County has a greater assemblage of remotely isolated relic-species and isolated endemics than any other botanically explored region between the Gaspé cliffs and mountains and The Driftless Area of Wisconsin, Minnesota, Iowa and Illinois." No generally accepted explanation for the presence of a number of plant novelties has yet appeared, although Fernald (1935) held to the idea of "nunataks," which were areas not covered by Wisconsin glacial ice, enabling certain parts of Keweenaw County, e.g., West Bluff, to serve as refugia. Richards (1952) repudiates the nunatak theory and his treatment of disjuncts and floristic affinities is the best account known for Keweenaw.

The first volume of the flora of Michigan (Voss, 1972), which treats monocots and gymnosperms, includes seven species known in Michigan only from the mainland of Keweenaw County; these are *Poa alpina, Agropyron spicatum, Danthonia intermedia, Muhlenbergia cuspidata, Phleum alpinum, Carex rossii,* and *C. media.* Three other species, *Bromus pubescens, Sisyrinchium albidum,* and *Aplectrum hyemale,* are found in at least 17 counties in the Lower Peninsula but are known only from Keweenaw County in the Upper Peninsula. Unknown from the Lower Peninsula and present in only two Upper Peninsula counties, including Keweenaw County, are *Carex praegracilis* and *C. atratiformis.* Other monocots rare in Michigan but included in the Keweenaw County flora are *Poa glauca, Trisetum spicatum, Muhlenbergia richardsonis, Calamagrostis stricta, Agrostis tenuis, Carex scirpoidea, C. pallescens,* and *Scirpus torreyi.*

There are several cordilleran species here that occur in the western mountains with no intermediate stations except for a few species known from the Black Hills. This group includes *Equisetum telmateia, Festuca occidentalis,* *Melica smithii, Crataegus douglasii, Chamaerhodos nuttallii, Rubus parviflorus, Ceanothus sanguineus, Vaccinium membranaceum, Adenocaulon bicolor,* and *Arnica cordifolia.* Additional cordilleran species, which also occur in the Upper St. Lawrence region, are *Woodsia oregana, Goodyera oblongifolia, Polygonum douglasii, Osmorhiza obtusa, O. chilensis, Vaccinium ovalifolium, Mimulus moschatus, Collinsia parviflora,* and *Lonicera involucrata.*

Arctic-alpine species of interest include *Poa alpina, Poa glauca, Polygonum viviparum, Sagina nodosa* and *Empetrum nigrum.* These and other disjunct elements in the Lake Superior flora are currently under study by Drs. James H. Soper and David R. Given of the National Museum of Natural Sciences, Ottawa, Canada.

CONCLUSIONS

The outstanding natural scenery of the Keweenaw is a most valuable economic resource, which requires protection by careful planning. Waterfalls, panoramic views, and scenic shorelines need to be preserved in their natural settings to remain attractive. The American people are placing increasing value on areas like the Keweenaw that possess truly unusual natural features.

Several floristic elements make up the flora of the Keweenaw region. Of these, the boreal and temperate constitute more than three-fourths of the total. Other elements include the arctic-alpine and cordilleran.

In view of the remarkable assortment of plants in this county it is important that well-formed plans be developed for protection of their habitats. As a result of our extensive survey covering all parts of this county we are in a position to recommend some of the most interesting areas which should be preserved. The Goodman Lumber Company and the Michigan Nature Association have made an excellent start in this program by the preservation of the unique 160-acre Estivant Pines tract. However, other types of communities are worthy of preservation. We were impressed by the forest cover along 932 Creek adjacent to Gratiot Lake, as well as by the stand of red and white pines near Lake Eliza, west of Eagle River. The strip of vegetation bordering Mandan Road has an unusual assemblage of exceptionally large trees of several species. This sector begins 1.7 miles south of the intersection with US 41 and continues for at least 2 miles.

In addition to these areas, we found excellent plant habitats at the sand dune community at Great Sand Bay and at Cat Harbor Bog near Eagle Harbor. Mt. Bohemia's tower offers an unusual panoramic view of a large portion of the Keweenaw quite different from the views from either East Bluff or West Bluff. It would seem important to maintain the integrity of the vegetation along stretches of the Montreal River.

The Keweenaw County Road Commission has done a remarkable job in the retention of natural features within its county park system as well as with design and placement of the few signs along its roadsides.

The extensive checklist of vascular plants, which follows, is evidence of the floristic diversity of this county. It includes 943 entities from over 100 families and represents more than a third of the species found in Michigan.

The interesting biotic communities and the large number of disjunct species found here can be attributed in part to the varied and rugged topography of the region.

CHECKLIST OF VASCULAR PLANTS OF KEWEENAW COUNTY (MAINLAND)

* = not native in Keweenaw County

LYCOPODIACEAE–Club-moss Family

Lycopodium alpinum L. Alpine Club-moss
L. annotinum L. Bristly Club-moss, Stiff Club-moss
L. clavatum L. Running-pine, Running Club-moss
L. flabelliforme (Fern.) Blanch. Running-pine, Running Ground-pine
L. inundatum L. Bog Club-moss
L. lucidulum Michx. Shining Club-moss
L. obscurum L. Ground-pine
L. selago L. Mountain Club-moss, Fir Club-moss
L. tristachyum Pursh Ground-cedar

SELAGINELLACEAE–Spike-moss Family

Selaginella rupestris (L.) Spring Rock Spike-moss
S. selaginoides (L.) Link Northern Spike-moss

EQUISETACEAE–Horsetail Family

Equisetum arvense L. Field Horsetail
E. fluviatile L. Water Horsetail
E. hyemale L. Scouring-rush
E. laevigatum A. Br. Smooth Scouring-rush
E. ×litorale Kuhl. Shore Horsetail
E. palustre L. Marsh Horsetail
E. pratense Ehrh. Shade Horsetail, Thicket Horsetail
E. scirpoides Michx. Dwarf Scouring-rush
E. sylvaticum L. Wood Horsetail
E. telmateia Ehrh. Giant Horsetail
E. variegatum Schleich. Variegated Scouring-rush

OPHIOGLOSSACEAE–Adder's-tongue Family

Botrychium dissectum Spreng. Cut-leaf Grape-fern
B. lanceolatum (Gmel.) Rupr. Lance-leaved Grape-fern
B. lunaria (L.) Sw. Moonwort
B. matricariaefolium A. Br. Matricary Grape-fern
B. multifidum (Gmel.) Rupr. Leathery Grape-fern
B. simplex E. Hitchc. Little Grape-fern, Dwarf Grape-fern
B. virginianum (L.) Sw. Rattlesnake Fern
Ophioglossum vulgatum L. Adder's-tongue Fern

OSMUNDACEAE–Royal Fern Family

Osmunda cinnamomea L. Cinnamon Fern
O. claytoniana L. Interrupted Fern
O. regalis L. Royal Fern

POLYPODIACEAE–Polypody Family

Adiantum pedatum L. Maidenhair
Asplenium montanum Willd. Mountain Spleenwort
A. ruta-muraria L. Wall-rue Spleenwort
A. trichomanes L. Maidenhair Spleenwort

Athyrium filix-femina (L.) Roth Lady Fern
Camptosorus rhizophyllus (L.) Link Walking Fern
Cystopteris bulbifera (L.) Bernh. Bulblet Fern
C. fragilis (L.) Bernh. Common Bladder-fern, Fragile Fern
Dryopteris cristata (L.) Gray Crested Wood-fern
D. filix-mas (L.) Schott Male Fern
D. fragrans (L.) Schott Fragrant Shield-fern, Fragrant Wood-fern
D. intermedia (Muhl.) Gray Evergreen Wood-fern
D. marginalis (L.) Gray Marginal Shield-fern, Marginal Wood-fern
D. spinulosa (O. F. Muell.) Watt. Spinulose Wood-fern
Gymnocarpium dryopteris (L.) Newm. Oak-fern
Matteuccia struthiopteris (L.) Todaro Ostrich Fern
Onoclea sensibilis L. Sensitive Fern
Pellaea atropurpurea (L.) Link Purple Cliffbrake
Polypodium vulgare L. Polypody
Polystichum acrostichoides (Michx.) Schott Christmas Fern
P. braunii (Spenner) Fee Braun's Holly Fern
P. lonchitis (L.) Roth Northern Holly Fern
Pteridium aquilinum (L.) Kuhn Bracken
Thelypteris hexagonoptera (Michx.) Weatherby Broad Beech-fern
T. palustris Schott Marsh Fern
T. phegopteris (L.) Slosson Northern Beech-fern
Woodsia alpina (Bolton) S. F. Gray Alpine Woodsia
W. ilvensis (L.) R. Br. Rusty Woodsia
W. obtusa (Spreng.) Torr. Blunt-lobed Woodsia
W. oregana D. C. Eaton Oregon Woodsia

TAXACEAE–Yew Family

Taxus canadensis Marsh. American Yew, Canada Yew

PINACEAE–Pine Family

Abies balsamea (L.) Mill. Balsam Fir
Larix laricina (Du Roi) K. Koch Tamarack
Picea glauca (Moench) Voss White Spruce
P. mariana (Mill.) BSP Black Spruce
Pinus banksiana Lamb. Jack Pine
P. resinosa Ait. Red Pine
P. strobus L. White Pine
Tsuga canadensis (L.) Carr. Hemlock

CUPRESSACEAE–Cypress Family

Juniperus communis L. var. *depressa* Pursh Ground Juniper, Low Juniper
J. horizontalis Moench Creeping Juniper
Thuja occidentalis L. White-cedar

TYPHACEAE–Cat-tail Family

Typha latifolia L. Broadleaf Cat-tail

SPARGANIACEAE–Bur-reed Family

Sparganium americanum Nutt. Nuttall's Bur-Reed
S. angustifolium Michx. Narrow-leaved Bur-Reed
S. chlorocarpum Rydb. Greenfruit Bur-Reed
S. fluctuans (Morong) Robins. Floating Bur-Reed
S. minimum (Hartm.) Fries Small Bur-Reed

POTOMAGETONACEAE–Pondweed Family

Potamogeton alpinus Balbis Northern Pondweed
P. amplifolius Tuckerm. Large-leaved Pondweed

P. berchtoldii Fieb. Berchtold Pondweed
P. epihydrus Raf. Nuttall's Pondweed
P. foliosus Raf. Leafy Pondweed
P. gramineus L. Grass-leaved Pondweed
P. natans L. Floating-leaved Pondweed
P. obtusifolius Mert. & Koch Blunt-leaved Pondweed
P. praelongus Wulfen White-stem Pondweed
P. pusillus L. Small Pondweed
P. richardsonii (Benn.) Rydb. Richardson's Pondweed
P. robbinsii Oakes Robbins' Pondweed
P. spirillus Tuckerm. Spiral Pondweed
P. strictifolius Benn. Stiff-leaved Pondweed
P. zosteriformis Fern. Flat-stemmed Pondweed

NAJADACEAE–Naiad Family

Najas flexilis (Willd.) Rostk. & Schmidt Bushy Pondweed

JUNCAGINACEAE–Arrowgrass Family

Scheuchzeria palustris L. Scheuchzeria
Triglochin maritimum L. Seaside Arrowgrass
T. palustre L. Marsh Arrowgrass

ALISMATACEAE–Water-plantain Family

Alisma plantago-aquatica L. Water-plantain
Sagittaria latifolia Willd. Common Arrowhead

HYDROCHARITACEAE–Frogbit Family

Elodea canadensis Michx. Waterweed
Vallisneria americana Michx. Tapegrass

GRAMINEAE–Grass Family

Agropyron dasystachyum (Hook.) Scribn. Northern Wheat Grass
**A. repens* (L.) Beauv. Quackgrass, Witch Grass
A. smithii Rydb. Western Wheat Grass
A. spicatum (Pursh) Scribn. & J. G. Smith Bluebunch Wheat Grass
A. trachycaulum (Link) Malte Slender Wheat Grass
Agrostis gigantea Roth Giant Redtop
A. hyemalis (Wlat.) BSP Ticklegrass
A. perennans (Walt.) Tuckerm. Autumn Bent
A. tenuis Sibth. Rhode Island Bent
Ammophila breviligulata Fern. Beach Grass
Anthoxanthum odoratum L. Sweet Vernal Grass
Aristida basiramea Vasey Three-awn Grass
Brachyelytrum erectum (Roth) Beauv. Woodgrass, Shortbeard Grass
Bromus ciliatus L. Fringed Brome
**B. inermis* Leyss. Smooth Brome
B. pubescens Willd. Canada Brome
**B. secalinus* L. Cheat
Calamagrostis canadensis (Michx.) Beauv. Blue-joint
C. inexpansa Gray Northern Reed Grass
C. stricta (Timm) Koeler Narrow Reed Grass
Cinna latifolia (Goepp.) Griseb. Wood Reed
**Dactylis glomerata* L. Orchard Grass
Danthonia intermedia Vasey Wild Oat Grass
D. spicata (L.) R. & S. Poverty Grass
**Deschampsia cespitosa* (L.) Beauv. Tufted Hairgrass
D. flexuosa (L.) Beauv. Common Hairgrass, Wavy Hairgrass
**Echinochloa crusgalli* (L.) Beauv. Barnyard Grass

E. muricata (Beauv.) Fern. Wild Millet, Barnyard Grass
Elymus glaucus Buckl. Wild Rye, Smooth Wild Rye
E. virginicus L. Terrell Grass, Virginia Wild Rye
Festuca occidentalis Hook. Western Fescue
**F. ovina* L. Sheep Fescue
**F. pratensis* Huds. Meadow Fescue
**F. rubra* L. Red Fescue
F. saximontana Rydb. Northern Fescue
Glyceria borealis (Nash) Batch. Floatgrass, Northern Manna Grass
G. canadensis (Michx.) Trin. Rattlesnake Grass
G. grandis Wats. Reed Manna Grass
G. striata (Lam.) Hitchc. Fowl Manna Grass
Hierochloë odorata (L.) Beauv. Sweet Grass
**Hordeum jubatum* L. Squirrel-tail Grass
**H. vulgare* L. Barley
Leersia oryzoides (L.) Sw. Cut Grass, Rice Cut Grass
Melica smithii (Gray) Vasey Melic Grass, Smith's Melic
Milium effusum L. Tall Millet
Muhlenbergia cuspidata (Hook.) Rydb. Plains Muhly
M. richardsonis (Trin.) Rydb. Richardson's Muhly
M. uniflora (Muhl.) Fern. One-flower Muhly
Oryzopsis asperifolia Michx. White-grain Rice Grass
O. pungens (Spreng.) Hitchc. Slender Rice Grass
Panicum boreale Nash Northern Panic Grass
P. capillare L. Witch Grass
P. columbianum Scribn. American Panic Grass
P. depauperatum Muhl. Starved Panic Grass
P. implicatum Britt. Woolly Panic Grass
P. linearifolium Britt. Slender-leaved Panic Grass
P. meridionale Ashe Matted Panic Grass
**P. miliaceum* L. Broomcorn Millet
P. xanthophysum Gray Yellow-fruited Panic Grass
Phalaris arundinacea L. Reed Canary Grass
Phleum alpinum L. Mountain Timothy
**P. pratense* L. Timothy
Phragmites australis (Cav.) Steud. Giant Reed
Poa alpina L. Alpine Spear Grass
**P. annua* L. Annual Blue Grass
**P. compressa* L. Canada Blue Grass
P. glauca Vahl Glaucous Spear Grass
P. nemoralis L. Wood Blue Grass
P. palustris L. Fowl Meadow Grass
**P. pratensis* L. Kentucky Blue Grass
P. saltuensis Fern. & Wieg. Northern Blue Grass
Puccinellia fernaldii (Hitchc.) E. Voss Meadow Grass
Schizachne purpurascens (Torr.) Swallen False Melic
**Setaria glauca* (L.) Beauv. Yellow Foxtail
**S. italica* (L.) Beauv. Millet Foxtail
**S. viridis* (L.) Beauv. Green Foxtail
Sphenopholis intermedia Vasey Slender Wedge Grass
S. obtusata (Michx.) Scribn. Prairie Wedge Grass
Sporobolus vaginiflorus (Torr.) Wood Sheathed Dropseed
Trisetum melicoides (Michx.) Scribn. False Oat
T. spicatum (L.) Richter Spiked False Oat
**Triticum aestivum* L. Wheat

CYPERACEAE–Sedge Family

Carex adusta Boott   Burnt Sedge
C. aenea Fern.   Copper Sedge
C. angustior Mack.   Slight Sedge
C. aquatilis Wahl.   Water Sedge
C. arcta Boott   Northern Cluster Sedge
C. arctata Boott   Drooping Wood Sedge
C. argyrantha Tuckerm.   Silver-flowered Sedge
C. atratiformis Britt.   Black Sedge
C. aurea Nutt.   Golden-fruited Sedge
C. backii Boott   Back's Sedge
C. bebbii (Bailey) Fern.   Bebb's Sedge
C. bromoides Willd.   Brome Sedge
C. brunnescens (Pers.) Poir.   Brown Sedge
C. buxbaumii Wahl.   Buxbaum's Sedge
C. canescens L.   Hoary Sedge
C. capillaris L.   Hair Sedge
C. castanea Wahl.   Chestnut Sedge
C. cephalantha (Bailey) Bickn.   Prickly Sedge
C. communis Bailey   Fibrous-rooted Sedge
C. conoidea Willd.   Field Sedge
C. crawei Dewey   Crawe's Sedge
C. crawfordii Fern.   Crawford's Sedge
C. crinita Lam.   Fringed Sedge
C. cristatella Britt.   Crested Sedge
C. cryptolepis Mack.   Hidden-scale Sedge
C. debilis Michx.   White-edged Sedge
C. deflexa Hornem.   Northern Sedge
C. deweyana Schw.   Dewey's Sedge
C. diandra Schrank   Panicled Sedge
C. disperma Dewey   Two-seeded Sedge, Soft-leaved Sedge
C. eburnea Boott   Bristle-leaved Sedge
C. exilis Dewey   Coast Sedge
C. flava L.   Yellow Sedge
C. foenea Willd.   Hay Sedge
C. garberi Fern.   Garber's Sedge
C. gracillima Schw.   Graceful Sedge
C. granularis Willd.   Meadow Sedge
C. gynandra Schw.   Nodding Sedge
C. gynocrates Drejer   Northern Bog Sedge
C. houghtoniana Torr.   Houghton's Sedge
C. hystericina Willd.   Bottlebrush Sedge, Porcupine Sedge
C. interior Bailey   Inland Sedge
C. intumescens Rudge   Bladder Sedge
C. lanuginosa Michx.   Woolly Sedge
C. lasiocarpa Ehrh.   Slender Sedge
C. lenticularis Michx.   Lenticular Sedge
C. leptalea Wahl.   Delicate Sedge, Bristle-stalked Sedge
C. leptonervia Fern.   Fine-nerved Sedge
C. limosa L.   Pond Sedge
C. livida (Wahl.) Willd.   Livid Sedge
C. media R. Br.   Boreal Sedge
C. merritt-fernaldii Mack.   Fernald's Sedge
C. michauxiana Boeckl.   Michaux's Sedge
C. oligosperma Michx.   Few-seeded Sedge

C. ormostachya Wieg. Beadlike Sedge
C. pallescens L. Pale Sedge
C. pauciflora Lightf. Few-flowered Sedge
C. paupercula Michx. Bog Sedge
C. peckii Howe White-tinged Sedge
C. pedunculata Willd. Stalked Sedge
C. pensylvanica Lam. Early Sedge, Pennsylvania Sedge
C. praegracilis W. Boott Thread-like Sedge
C. praticola Rydb. Prairie Sedge
C. projecta Mack. Beaded Broomsedge
C. pseudo-cyperus L. Cyperus Sedge
C. retrorsa Schw. Hooked Sedge
C. richardsonii R. Br. Richardson's Sedge
C. rossii Boott Ross's Sedge
C. rostrata Stokes Beaked Sedge
C. rugosperma Mack. Rough-fruited Sedge
C. scabrata Schw. Rough Sedge
C. scirpoidea Michx. Scirpus Sedge
C. scoparia Willd. Broom Sedge
C. sprengelii Dewey Long-beaked Sedge
C. sterilis Willd. Sterile Sedge
C. stipata Willd. Awl-fruited Sedge
C. stricta Lam. Hassock Sedge
C. tenuiflora Wahl. Sparse-flowered Sedge
C. tetanica Schk. Wood's Sedge
C. tribuloides Wahl. Blunt Broomsedge
C. trisperma Dewey Three-fruited Sedge
C. tuckermanii Dewey Tuckerman's Sedge
C. umbellata Willd. Umbelled Sedge
C. vaginata Tausch Sheathed Sedge
C. vesicaria L. Inflated Sedge
C. viridula Michx. Green Sedge
C. vulpinoidea Michx. Fox Sedge
Dulichium arundinaceum (L.) Britt. Three-way Sedge
Eleocharis acicularis (L.) R. & S. Needle Spikerush
E. elliptica Kunth Capitate Spikerush
E. erythropoda Steud. Bald Spikerush
E. obtusa (Willd.) Schult. Blunt Spikerush
E. ovata (Roth) R. & S. Ovoid Spikerush
E. pauciflora (Lightf.) Link. Few-flowered Spikerush
E. robbinsii Oakes Robbins' Spikerush
E. smallii Britt. Small's Spikerush
Eriophorum angustifolium Honck. Narrow-leaved Cotton-grass
E. gracile Koch Slender Cotton-grass
E. spissum Fern. Sheathed Cotton-grass
E. tenellum Nutt. Rough Cotton-grass
E. virginicum L. Rusty Cotton-grass
E. viridi-carinatum (Engelm.) Fern. Tall Cotton-grass
Rhynchospora alba (L.) Vahl. White Beak-rush
R. fusca (L.) Ait. f. Brown Beak-rush
Scirpus acutus Bigel. Hard-stemmed Bulrush
S. americanus Pers. Three-square Bulrush
S. atrovirens Willd. Dark-green Bulrush
S. cespitosus L. Tufted Clubrush
S. cyperinus (L.) Kunth Woolgrass
S. hudsonianus (Michx.) Fern. Alpine Cotton-grass

S. microcarpus Presl Small-fruited Bulrush
S. pendulus Muhl. Drooping Bulrush
S. subterminalis Torr. Water Clubrush
S. torreyi Olney Torrey's Bulrush
S. validus Vahl. Great Bulrush

ARACEAE–Arum Family

Arisaema triphyllum (L.) Schott Jack-in-the-pulpit
Calla palustris L. Wild Calla
Symplocarpus foetidus (L.) Nutt. Skunk Cabbage

LEMNACEAE–Duckweed Family

Lemna minor L. Duckweed

ERIOCAULACEAE–Pipewort Family

Eriocaulon septangulare With. Pipewort

JUNCACEAE–Rush Family

Juncus alpinus Vill. Alpine Rush
J. articulatus L. Joint Rush
J. balticus Willd. Lake Shore Rush
J. brachycephalus (Engelm.) Buch. Small-headed Rush
J. brevicaudatus (Engelm.) Fern. Narrow-panicled Rush
J. bufonius L. Toad Rush
J. canadensis La Harpe Canada Rush
J. dudleyi Wieg. Dudley's Rush
J. effusus L. Soft Rush
J. filiformis L. Thread Rush
J. greenei Oakes & Tuckerm. Greene's Rush
J. nodosus L. Joint Rush, Knotted Rush
J. tenuis Willd. Path Rush, Slender Rush

LILIACEAE–Lily Family

Allium schoenoprasum L. Chives
**Asparagus officinalis* L. Asparagus
Clintonia borealis (Ait.) Raf. Bluebead Lily, Clintonia
Erythronium americanum Ker Yellow Trout-lily
Lilium philadelphicum L. Wood Lily
Maianthemum canadense Desf. Canada Mayflower
Polygonatum pubescens (Willd.) Pursh Solomon's Seal
Smilacina racemosa (L.) Desf. False Spikenard
S. trifolia (L.) Desf. Three-leaved Solomon's Seal
Streptopus amplexifolius (L.) DC. Giant Twisted-stalk
S. roseus Michx. Twisted-stalk
Trillium cernuum L. Nodding Trillium
T. grandiflorum (Michx.) Salisb. Large White Trillium
Tofieldia glutinosa (Michx.) Pers. False Asphodel

IRIDACEAE–Iris Family

Iris versicolor L. Wild Blue Flag, Wild Iris
Sisyrinchium albidum Raf. Pale Blue-eyed-grass
S. angustifolium Mill. Stout Blue-eyed-grass
S. montanum Greene Pointed Blue-eyed-grass

ORCHIDACEAE–Orchid Family

Aplectrum hyemale (Wild.) Torr. Putty-root
Arethusa bulbosa L. Arethusa, Swamp-pink
Calopogon tuberosus (L.) BSP Grass-pink

Calypso bulbosa (L.) Oakes Calypso
Corallorhiza maculata Raf. Spotted Coral-root
C. striata Lindl. Striped Coral-root
C. trifida Chat. Early Coral-root
Cypripedium acaule Ait. Pink Lady-slipper
C. arietinum R. Br. Ram's Head Lady-slipper
C. calceolus L. Yellow Lady-slipper
C. reginae Walt. Showy Lady-slipper
Goodyera oblongifolia Raf. Rattlesnake-plantain
G. pubescens (Willd.) R. Br. Downy Rattlesnake-plantain
G. repens (L.) R. Br. Lesser Rattlesnake-plantain
G. tesselata Lodd. Rattlesnake-plantain
Habenaria clavellata (Michx.) Spreng. Club-spur Orchid
H. dilatata (Pursh) Hook. Bog Candle
H. hookeri Gray Hooker's Orchid
H. hyperborea (L.) R. Br. Tall Northern Bog Orchid
H. lacera (Michx.) Lodd. Ragged Fringed Orchid
H.×media (Rydb.) Niles
H. obtusata (Pursh) Richards. Blunt-leaved Orchid
H. orbiculata (Pursh) Torr. Round-leaved Orchid
H. psycodes (L.) Spreng. Purple Fringed Orchid
H. viridis (L.) R. Br. Bracted Orchid
Listera convallarioides (Sw.) Torr. Broad-leaved Twayblade
L. cordata (L.) R. Br. Heartleaved Twayblade
Liparis loeselii (L.) Rich. Loesel's Twayblade
Malaxis monophylla (L.) Sw. White Adder's-mouth
M. unifolia Michx. Green Adder's-mouth
Pogonia ophioglossoides (L.) Ker Rose Pogonia
Spiranthes cernua (L.) Rich. Nodding Ladies'-tresses
S. lacera (Raf.) Raf. Slender Ladies'-tresses
S. romanzoffiana Cham. Hooded Ladies'-tresses

SALICACEAE–Willow Family

Populus balsamifera L. Balsam Poplar
P. grandidentata Michx. Large-toothed Aspen
P. tremuloides Michx. Quaking Aspen
Salix bebbiana Sarg. Long-beaked Willow, Bebb's Willow
**S. caprea* L. Goat-willow
S. discolor Muhl. Large Pussy-willow
S. humilis Marsh. Small Pussy-willow, Upland Willow
S. lucida Muhl. Shining Willow
S. pedicellaris Pursh Bog Willow
S. petiolaris Sm. Slender Willow
S. pyrifolia Anderss. Balsam Willow

MYRICACEAE–Bayberry Family

Comptonia peregrina (L.) Coult. Sweet-fern
Myrica gale L. Sweet Gale

BETULACEAE–Birch Family

Alnus crispa (Ait.) Pursh Green Alder
A. rugosa (Du Roi) Spreng. Speckled Alder
Betula alleghaniensis Britt. Yellow Birch
B. glandulosa Michx. Dwarf Birch
B. papyrifera Marsh. Paper Birch
B. pumila L. Swamp Birch
Corylus cornuta Marsh. Beaked Hazelnut
Ostrya virginiana (Mill.) K. Koch Hop-hornbeam, Ironwood

FAGACEAE–Beech Family

Quercus borealis Michx. f. Northern Red Oak
Q. ellipsoidalis E. J. Hill Jack Oak, Northern Pin Oak

ULMACEAE–Elm Family

Ulmus americana L. American Elm

URTICACEAE–Nettle Family

Urtica dioica L. Stinging Nettle

LORANTHACEAE–Mistletoe Family

Arceuthobium pusillum Peck Dwarf Mistletoe

SANTALACEAE–Sandalwood Family

Comandra livida Richards. Northern False Toadflax
C. richardsiana Fern. False Toadflax

ARISTOLOCHIACEAE–Birthwort Family

Asarum canadense L. Wild-ginger

POLYGONACEAE–Smartweed Family

Polygonella articulata (L.) Meissn. Jointweed
Polygonum achoreum Blake Leathery Knotweed
**P. aviculare* L. Creeping Knotweed
P. cilinode Michx. Fringed Bindweed
**P. convolvulus* L. Black Bindweed
P. douglasii Greene Douglas' Knotweed
**P. hydropiper* L. Water-pepper
P. lapathifolium L. Heart's Ease, Dock-leaved Smartweed
P. natans Eat Water Smartweed
**P. persicaria* L. Lady's-thumb
P. punctatum Ell. Dotted Smartweed
P. viviparum L. Bistort
**Rumex acetosella* L. Sheep-sorrel
**R. crispus* L. Curly Dock
R. mexicanus Meissn. Mexican Dock
**R. obtusifolius* L. Bitter Dock, Blunt-leaved Dock

CHENOPODIACEAE–Goosefoot Family

Atriplex patula L. Spearscale
**Chenopodium album* L. Lamb's Quarters
**C. botrys* L. Jerusalem-oak
C. capitatum (L.) Aschers. Strawberry-blite
**C. glaucum* L. Oak-leaved Goosefoot
**Salsola kali* L. Common Saltwort, Russian-thistle

AMARANTHACEAE–Amaranth Family

Amaranthus albus L. Tumbleweed
A. graecizans L. Prostrate Amaranth

AIZOACEAE–Carpetweed Family

**Mollugo verticillata* L. Carpetweed

PORTULACACEAE–Purslane Family

Claytonia caroliniana Michx. Spring Beauty

CARYOPHYLLACEAE–Pink Family

**Arenaria serpyllifolia* L. Thyme-leaved Sandwort
A. stricta Michx. Rock Sandwort
Cerastium arvense L. Field Chickweed

**C. semidecandrum* L. Small Mouse-ear Chickweed
**C. vulgatum* L. Large Mouse-ear Chickweed
**Dianthus armeria* L. Deptford Pink
**D. barbatus* L. Sweet William
**D. deltoides* L. Maiden Pink, Meadow Pink
**D. plumarius* L. Grass Pink, Garden Pink
**Lychnis alba* Mill. White Campion
**L. chalcedonica* L. Scarlet Lychnis
**L. coronaria* (L.) Desr. Mullein Pink
Sagina nodosa (L.) Fenzl Knotted Pearlwort
S. procumbens L. Birdseye, Low Pearlwort
**Saponaria officinalis* L. Soapwort, Bouncing Bet
**Silene antirrhina* L. Sleepy Catchfly
**S. cserei* Baumg. Smooth Campion
**S. cucubalus* Wibel Bladder Campion
**S. dichotoma* Ehrh. Forked Catchfly
Spergularia rubra (L.) J. & C. Presl Sand Spurry
Stellaria calycantha (Ledeb.) Bong. Northern Chickweed
**S. graminea* L. Common Stitchwort, Lesser Chickweed
S. longifolia Muhl. Long-leaved Chickweed
**Vaccaria segetalis* (Neck.) Garcke Cowherb

NYMPHAEACEAE–Water-lily Family

Brasenia schreberi Gmel. Water-shield
Nuphar advena (Ait.) Ait. f. Yellow Pond-lily
N. variegatum Engelm. Bullhead-lily, Variegated Pond-lily
Nymphaea odorata Ait. Fragrant Water-lily

RANUNCULACEAE–Crowfoot Family

Actaea alba (L.) Mill. White Baneberry
A. rubra (Ait.) Willd. Red Baneberry
Anemone canadensis L. Canada Anemone
A. quinquefolia L. Wood Anemone
A. riparia Fern. River Anemone
A. virginiana L. Thimbleweed
Anemonella thalictroides (L.) Spach Rue-anemone
Aquilegia canadensis L. Columbine
**A. vulgaris* L. Garden Columbine
Caltha palustris L. Marsh-marigold
Clematis verticillaris DC. Purple Clematis
C. virginiana L. Virgin's-bower
Coptis trifolia (L.) Salisb. Goldthread
**Delphinium ×cultorum* Voss Delphinium
Hepatica americana (DC.) Ker Roundleaved Hepatica
Ranunculus abortivus L. Small-flowered Crowfoot
**R. acris* L. Tall Buttercup
R. aquatilis L. White Water-crowfoot
**R. bulbosus* L. Bulb Buttercup
R. circinatus Sibth. White Water-crowfoot
R. flammula L. Spearwort
R. pensylvanicus L. f. Bristly Crowfoot
R. recurvatus Poir. Hooked Crowfoot
R. septentrionalis Poir. Swamp Buttercup
Thalictrum dasycarpum Fisch. & Ave-Lall. Purple Meadow-rue

PAPAVERACEAE–Poppy Family

Sanguinaria canadensis L. Bloodroot

FUMARIACEAE–Fumitory Family

Corydalis aurea Willd. Golden Corydalis
C. sempervirens (L.) Pers. Pale Corydalis, Pink Corydalis

CRUCIFERAE–Mustard Family

Arabis divaricarpa A. Nels. Purple Rockcress
A. drummondii Gray Drummond's Rockcress
A. glabra (L.) Bernh. Tower Mustard
A. hirsuta (L.) Scop. Hairy Rockcress
A. holboellii Hornem. Holboell's Rockcress
A. laevigata (Muhl.) Poir. Bank Cress, Smooth Rockcress
A. lyrata L. Lyre-leaved Rockcress
**Armoracia rusticana* Gaertn. Horse Radish
**Barbarea vulgaris* R. Br. Yellow Rocket, Winter Cress
**Berteroa incana* (L.) DC. Hoary Alyssum
**Brassica hirta* Moench White Mustard
**B. juncea* (L.) Cosson Brown Mustard, Indian Mustard
**B. kaber* (DC.) L. C. Wheeler Charlock
**B. nigra* (L.) Koch Black Mustard
Braya humilis (C. A. Meyer) Robins. Northern Rockcress
**Camelina sativa* (L.) Crantz. Gold-of-pleasure, Falseflax
**Capsella bursa-pastoris* (L.) Medic. Shepherd's-purse
Cardamine parviflora L. Small-flowered Bittercress
C. pensylvanica Muhl. Pennsylvania Bittercress
C. pratensis L. Cuckoo-flower
**Conringia orientalis* (L.) Andrz. Hare's-ear-mustard
Dentaria diphylla Michx. Crinkleroot
D. laciniata Muhl. Cut-leaved Toothwort
Descurainia pinnata (Walt.) Britt. Tansy-mustard
Draba arabisans Michx. Rock Cress
**Erucastrum gallicum* (Willd.) O. E. Schulz Dog-mustard
**Erysimum cheiranthoides* L. Wormseed-mustard
**E. inconspicuum* (Wats.) MacMill. Small Wormseed-mustard
Lepidium densiflorum Schrader Small Peppergrass
Rorippa islandica (Oeder) Borbas Marsh Cress
**Sisymbrium altissimum* L. Tumble-mustard
**S. officinale* (L.) Scop. Hedge-mustard
**Thlaspi arvense* L. Penny-cress

SARRACENIACEAE–Pitcher-plant Family

Sarracenia purpurea L. Pitcher-plnat

DROSERACEAE–Sundew Family

Drosera intermedia Hayne Spatulate-leaved Sundew
D. linearis Goldie Slender-leaved Sundew
D. rotundifolia L. Round-leaved Sundew

CRASSULACEAE–Orpine Family

**Sedum acre* L. Mossy Stonecrop
**S. telephium* L. Live-forever

SAXIFRAGACEAE–Saxifrage Family

Chrysosplenium americanum Schw. Golden Saxifrage
Mitella nuda L. Nude Mitrewort
Parnassia palustris L. Grass-of-Parnassus
Ribes glandulosum Grauer Skunk Currant
R. hudsonianum Richards. Northern Black Currant

R. lacustre (Pers.) Poir. Bristly Black Gooseberry
R. oxyacanthoides L. Northern Gooseberry
**R. sativum* Syme Currant
R. triste Pall. Red Currant, Swamp Currant
Saxifraga virginiensis Michx. Early Saxifrage

ROSACEAE–Rose Family

Agrimonia gryposepala Wallr. Agrimony
Amelanchier bartramiana (Tausch) Roem. Bartram's Shadbush
A. interior Nielsen Inland Serviceberry, Inland Shadbush
A. laevis Wieg. Allegheny Shadbush
A. laevis Wieg. × *sanguinea* (Pursh) DC. Shadbush
A. sanguinea (Pursh) DC. Round-leaved Shadbush
A. spicata (Lam.) K. Koch Low Shadbush
Chamaerhodos nuttallii Pickering American Chamaerhodos
Crataegus chrysocarpa Ashe Round-leaved Hawthorn
C. douglasii Lindl. Douglas' Hawthorn
C. irrasa Sarg. Blanchard's Hawthorn
C. macrosperma Ashe Variable Hawthorn
C. succulenta Link Longspine Hawthorn
Fragaria vesca L. Woodland Strawberry
F. virginiana Duchesne Strawberry
Geum aleppicum Jacq. Yellow Avens
G. rivale L. Purple Avens
Physocarpus opulifolius (L.) Maxim. Ninebark
Potentilla anserina L. Silverweed
**P. argentea* L. Silvery Cinquefoil
P. arguta Pursh Tall Cinquefoil
P. canadensis L. Creeping Cinquefoil
P. fruticosa L. Shrubby Cinquefoil
P. gracilis Dougl. Slender Cinquefoil
P. intermedia L. Gray Cinquefoil
P. norvegica L. Rough Cinquefoil
P. palustris (L.) Scop. Marsh Cinquefoil
P. pensylvanica L. Prairie Cinquefoil
**P. recta* L. Sulfur Cinquefoil, Pale Cinquefoil
P. simplex Michx. Old-field Cinquefoil
P. tridentata Ait. Three-toothed Cinquefoil
Prunus pensylvanica L. f. Pin Cherry
P. pumila L. Sand Cherry
P. serotina Ehrh. Black Cherry
P. virginiana L. Choke Cherry
**Pyrus malus* L. Apple
Rosa acicularis Lindl. Prickly Rose
R. blanda Ait. Smooth Rose
R. carolina L. Pasture Rose
**R. eglanteria* L. Sweetbrier
R. palustris Marsh. Swamp Rose
**R. spinossissima* L. Scotch Rose
R. suffulta Greene Arkansas Rose
Rubus alleghaniensis Porter Common Blackberry
R. canadensis L. Smooth Blackberry
R. flagellaris L. Northern Dewberry
R. parviflorus Nutt. Thimbleberry
R. pensylvanicus Poir. Pennsylvania Blackberry
R. pubescens Raf. Dwarf Raspberry

R. setosus Bigel. Bristly Blackberry
R. strigosus Michx. Red Raspberry
Sorbus americana Marsh. American Mountain Ash
S. decora (Sarg.) Schneid. Showy Mountain Ash
Spiraea alba Du Roi Meadow-sweet
S. latifolia (Ait.) Borkh. Broad-leaved Meadowsweet
Waldsteinia fragarioides (Michx.) Tratt. Barren Strawberry

FABACEAE–Bean Family

**Lathyrus latifolius* L. Everlasting Pea
L. maritimus (L.) Bigel. Beach Pea
L. ochroleucus Hook. Pale Vetchling
**L. pratensis* L. Yellow Vetchling
**L. sylvestris* L. Everlasting Pea
**L. tuberosus* L. Tuberous or Purple Vetchling
L. venosus Muhl. Veiny Pea
**Lupinus polyphyllus* Lindl. Giant Lupine
**Medicago lupulina* L. Black Medic
**M. sativa* L. Alfalfa
**Melilotus officinalis* (L.) Lam. Yellow Sweet Clover
**Robinia pseudo-acacia* L. Black Locust
**Trifolium agrarium* L. Yellow Hop Clover
**T. arvense* L. Rabbit-foot Clover
**T. hybridum* L. Alsike or Pink Clover
**T. incarnatum* L. Scarlet or Buffalo Clover
**T. pratense* L. Red Clover
**T. repens* L. White Clover
Vicia americana Muhl. American Vetch
V. caroliniana Walt. Carolina Vetch
**V. cracca* L. Tufted or Cow Vetch
**V. sativa* L. Spring Vetch
**V. villosa* Roth Hairy Vetch

OXALIDACEAE–Wood Sorrel Family

Oxalis acetosella L. Wood or Mountain Sorrel

GERANIACEAE–Geranium Family

**Erodium cicutarium* (L.) L'Hér. Storksbill
Geranium bicknellii Britt. Bicknell's Geranium
**G. carolinianum* L. Carolina Geranium
**G. pusillum* L. Small Geranium
G. robertianum L. Herb-Robert

LINACEAE–Flax Family

**Linum catharticum* L. Fairy or Dwarf Flax
**L. usitatissimum* L. Common Flax

POLYGALACEAE–Milkwort Family

Polygala paucifolia Willd. Fringed Polygala

EUPHORBIACEAE–Spurge Family

**Euphorbia cyparissias* L. Cypress Spurge
E. glyptosperma Engelm. Ridge-seeded Spurge
E. serpyllifolia Pers. Thyme-leaved Spurge

CALLITRICHACEAE–Water-starwort Family

Callitriche hermaphroditica L. Furrowed Water-starwort
C. palustris L. Spring Water-starwort

EMPETRACEAE–Crowberry Family

Empetrum nigrum L. Black Crowberry

ANACARDIACEAE–Cashew Family

Rhus glabra L. Smooth Sumac
R. radicans L. Poison-ivy

AQUIFOLIACEAE–Holly Family

Ilex verticillata (L.) Gray Michigan Holly, Winterberry
Nemopanthus mucronatus (L.) Trel. Mountain Holly

CELASTRACEAE–Staff-tree Family

Celastrus scandens L. Bittersweet

ACERACEAE–Maple Family

Acer negundo L. Box Elder
A. rubrum L. Red Maple
A. saccharum Marsh. Sugar Maple
A. spicatum Lam. Mountain Maple

BALSAMINACEAE–Touch-me-not Family

Impatiens biflora Walt. Touch-me-not, Jewelweed

RHAMNACEAE–Buckthorn Family

Ceanothus ovatus Desf. Redroot, Inland New Jersey Tea
C. sanguineus Pursh Wild-lilac, Western New Jersey Tea
Rhamnus alnifolia L'Her. Bog Buckthorn

VITACEAE–Grape Family

Parthenocissus quinquefolia (L.) Planch. Virginia Creeper

TILIACEAE–Linden Family

Tilia americana L. Basswood

MALVACEAE–Mallow Family

**Malva moschata* L. Musk Mallow
**M. neglecta* Wallr. Common Mallow
**M. rotundifolia* L. Round-leaved Mallow

HYPERICACEAE–St. John's-wort Family

Hypericum boreale (Britt.) Bickn. Northern St. John's-wort
H. canadense L. Canada St. John's-wort
H. ellipticum Hook. Pale St. John's-wort
**H. perforatum* L. Common St. John's-wort
H. pyramidatum Ait. Giant St. John's-wort
Triadenum fraseri (Spach) Gl. Marsh St. John's-wort

CISTACEAE–Rockrose Family

Hudsonia tomentosa Nutt. False Heather

VIOLACEAE–Violet Family

Viola adunca Sm. Largespur Violet
V. conspersa Reichenb. Dog Violet
V. cucullata Ait. Marsh Blue Violet
V. incognita Brainerd Large-leaved White Violet
V. lanceolata L. Lance-leaved Violet
V. nephrophylla Greene Northern Bog Violet
V. pallens (Banks) Brainerd Smooth White Violet
V. eriocarpa Schw. Smooth Yellow Violet

V. pubescens Ait. Downy Yellow Violet
V. renifolia Gray Kidney-leaved White Violet
V. selkirkii Pursh Great Spurred Violet
V. septentrionalis Greene Northern Blue Violet
V. striata Ait. Cream Violet
**V. tricolor* L. Garden Violet, Pansy

THYMELAEACEAE–Mezereum Family

Dirca palustris L. Leatherwood

ELAEAGNACEAE–Oleaster Family

Shepherdia canadensis (L.) Nutt. Buffalo Berry

LYTHRACEAE–Loosestrife Family

**Lythrum salicaria* L. Purple Loosestrife

ONAGRACEAE–Evening-primrose Family

Circaea alpina L. Alpine Enchanter's Nightshade
Epilobium adenocaulon Haussk. Northern Willow-herb
E. angustifolium L. Fireweed
E. coloratum Biehler Cinnamon or Purple-leaved Willow-herb
E. leptophyllum Raf. Bog Willow-herb
E. strictum Muhl. Downy Willow-herb
Oenothera parviflora L. Northern Evening-primrose
O. perennis L. Sundrops
O. strigosa (Rydb.) Mack. & Bush Western Evening-primrose

HALORAGIDACEAE–Water-milfoil Family

Myriophyllum exalbescens Fern. Spiked Water-milfoil
M. farwellii Morong Farwell's Water-milfoil
M. verticillatum L. Whorled Water-milfoil

HIPPURIDACEAE–Mare's-tail Family

Hippuris vulgaris L. Mare's-tail

ARALIACEAE–Ginseng Family

Aralia hispida Vent. Bristly Sarsaparilla
A. nudicaulis L. Wild Sarsaparilla
A. racemosa L. Spikenard
Panax trifolium L. Dwarf Ginseng

UMBELLIFERAE–Parsley Family

**Carum carvi* L. Caraway
**Daucus carota* L. Wild Carrot, Queen Anne's Lace
Heracleum lanatum Michx. Cow-parsnip
**Pastinaca sativa* L. Wild Parsnip
Osmorhiza chilensis H. & A. Northern Sweet Cicely
O. obtusa (Coult. & Rose) Fern. Sweet Cicely
Sanicula marilandica L. Black Snakeroot
Sium suave Walt. Water-parsnip
Taenidia integerrima (L.) Drude Yellow Pimpernel
Zizia aurea (L.) Koch Golden Alexanders

CORNACEAE–Dogwood Family

Cornus alternifolia L. f. Alternate-leaved Dogwood
C. canadensis L. Bunchberry
C. rugosa Lam. Round-leaved Dogwood
C. stolonifera Michx. Red Osier Dogwood

ERICACEAE–Heath Family

Andromeda glaucophylla Link. Bog-rosemary
Arctostaphylos uva-ursi (L.) Spreng. Bearberry
Chamaedaphne calyculata (L.) Moench Leatherleaf
Chimaphila umbellata (L.) Bart. Prince's-pine
Epigaea repens L. Trailing Arbutus
Gaylussacia baccata (Wang.) K. Koch Huckleberry
Gaultheria hispidula (L.) Muhl. Creeping-snowberry
G. procumbens L. Wintergreen
Kalmia polifolia Wang. Swamp Laurel
Ledum groenlandicum Oeder Labrador-tea
Moneses uniflora (L.) Gray One-flowered Shinleaf
Monotropa hypopithys L. Pinesap
M. uniflora L. Indian Pipe
Pterospora andromedea Nutt. Pine-drops
Pyrola asarifolia Michx. Pink or Bog Shinleaf
P. elliptica Nutt. Elliptic Shinleaf
P. rotundifolia L. Round Shinleaf
P. secunda L. One-sided Shinleaf
P. virens Schweigg. Greenish Shinleaf
Vaccinium angustifolium Ait. Low Blueberry
V. brittonii Porter Black Blueberry
V. corymbosum L. Highbush Blueberry
V. lamarckii Camp Lamarck's Blueberry
V. macrocarpon Ait. Large Cranberry
V. membranaceum Dougl. Bilberry
V. myrtilloides Michx. Velvet-leaved Blueberry
V. ovalifolium Smith Oval-leaved Bilberry
V. oxycoccos L. Small Cranberry
V. vacillans Torr. Dryland Blueberry

PRIMULACEAE–Primrose Family

Lysimachia terrestris (L.) BSP Swamp Loosestrife, Swamp Candle
Naumburgia thyrsiflora (L.) Duby Tufted Loosestrife
Primula mistassinica Michx. Bird's-eye Primrose
Trientalis borealis Raf. Star-flower

OLEACEAE–Olive Family

Fraxinus americana L. White Ash
F. nigra Marsh. Black Ash
F. pennsylvanica Marsh. Red Ash

GENTIANACEAE–Gentian Family

Gentiana rubricaulis Schwein. Northern Gentian
Halenia deflexa (Sm.) Griseb. Spurred Gentian
Menyanthes trifoliata L. Bog Buckbean

APOCYNACEAE–Dogbane Family

Apocynum androsaemifolium L. Spreading Dogbane
**Vinca minor* L. Periwinkle, Creeping Myrtle

ASCLEPIADACEAE–Milkweed Family

Asclepias syriaca L. Common Milkweed

CONVOLVULACEAE–Morning-glory Family

**Convolvulus arvensis* L. Field Bindweed
C. spithamaeus L. Low Bindweed

POLEMONIACEAE–Phlox Family

Phlox paniculata L. Garden Phlox
**P. subulata* L. Moss-pink

BORAGINACEAE–Borage Family

**Borago officinalis* L. Borage
Cynoglossum boreale Fern. Northern Wild Comfrey
**C. officinale* L. Hound's-tongue
Hackelia virginiana (L.) Johnst. Stickseed
**Lappula echinata* Gilib. Beggar's Lice
Mertensia paniculata (Ait.) G. Don. Northern Bluebell
Myosotis laxa Lehm. Small Forget-me-not
**M. scorpioides* L. Forget-me-not
M. virginica (L.) BSP Spring Scorpion-grass

VERBENACEAE–Vervain Family

**Verbena bracteata* Lag. & Rodr. Creeping Vervain

LABIATAE–Mint Family

Dracocephalum formosius (Lunell) Rydb. False Dragonhead
Galeopsis tetrahit L. Hemp-nettle
**Glecoma hederacea* L. Ground-ivy
Lycopus americanus Muhl. Cutleaf Water-horehound
L. uniflorus Michx. Northern Bugleweed
Mentha arvensis L. Corn Mint
**M. piperita* L. Peppermint
**M. spicata* L. Spearmint
Moldavica parviflora (Nutt.) Britt. American Dragonhead
**Nepeta cataria* L. Catnip
Prunella vulgaris L. Self-heal, Heal-all
**Satureja vulgaris* (L.) Fritsch Wild Basil
Scutellaria galericulata L. Marsh Skullcap
S. lateriflora L. Mad-dog Skullcap
Stachys palustris L. Hedge-nettle

SOLANACEAE–Nightshade Family

Physalis grandiflora Hook. Large Ground-cherry
P. heterophylla Nees Clammy Ground-cherry
P. virginiana Mill. Lance-leaved Ground-cherry
**Solanum dulcamara* L. Bittersweet Nightshade

SCROPHULARIACEAE–Figwort Family

Castilleja coccinea (L.) Spreng. Indian Paint-brush
C. septentrionalis Lindl. Cream Paint-brush
Chelone glabra L. Turtlehead
Collinsia parviflora Dougl. Small-flowered Collinsia
**Linaria vulgaris* Hill Butter-and-eggs
Melampyrum lineare Desr. Cow-wheat
**Mimulus moschatus* Dougl. Musk-flower
M. ringens L. Monkey Flower
Pedicularis canadensis L. Wood Betony
Scrophularia lanceolata Pursh Early Figwort
**Verbascum thapsus* L. Common Mullein
Veronica americana (Raf.) Schw. Brooklime
V. anagallis-aquatica L. Water Speedwell
**V. arvensis* L. Corn Speedwell
**V. chamaedrys* L. Germander Speedwell

**V. officinalis* L. Common Speedwell
**V. serpyllifolia* L. Thyme-leaved Speedwell
**V. verna* L. Spring Speedwell

OROBANCHACEAE–Broomrape Family

Conopholis americana (L.) Wallr. Squawroot

LENTIBULARIACEAE–Bladderwort Family

Pinguicula vulgaris L. Butterwort
Utricularia cornuta Michx. Horned Bladderwort
U. vulgaris L. Large Bladderwort

PLANTAGINACEAE–Plantain Family

**Plantago altissima* L. Tall Plantain
**P. lanceolata* L. English Plantain
**P. major* L. Common Plantain
P. rugelii Dcne. Red-stemmed or Rugel's Plantain

RUBIACEAE–Madder Family

Galium aparine L. Early Bedstraw
G. asprellum Michx. Rough Bedstraw
G. boreale L. Northern Bedstraw
G. obtusum Bigel. Wild Madder
G. tinctorium L. Stiff Bedstraw
G. trifidum L. Small Bedstraw
G. triflorum Michx. Sweet-scented Bedstraw
Mitchella repens L. Partridge-berry

CAPRIFOLIACEAE–Honeysuckle Family

Diervilla lonicera Mill. Bush-honeysuckle
Linnaea borealis L. Twin-flower
Lonicera canadensis Marsh. Fly Honeysuckle, Canada Honeysuckle
L. dioica L. Twining Honeysuckle
L. hirsuta Eat. Hairy Honeysuckle
L. involucrata (Richards.) Banks Involucred Fly Honeysuckle
L. oblongifolia (Goldie) Hook. Swamp Fly Honeysuckle
L. prolifera (Kirchner) Rehder Grape Honeysuckle
L. villosa (Michx.) R. & S. Mountain Fly Honeysuckle
Sambucus canadensis L. Common Elder
S. pubens Michx. Red-berried Elder
Symphoricarpus albus (L.) Blake Snowberry
S. occidentalis Hook. Wolfberry
S. orbiculatus Moench Indian-currant
Viburnum opulus L. Highbush-cranberry
V. rafinesquianum Schult. Downy Arrowwood

CUCURBITACEAE–Gourd Family

Echinocystis lobata (Michx.) T. & G. Wild Cucumber

CAMPANULACEAE–Harebell Family

Campanula aparinoides Pursh. Marsh Bellflower
**C. rapunculoides* L. Bellflower
C. rotundifolia L. Harebell

LOBELIACEAE–Lobelia Family

Lobelia dortmanna L. Water Lobelia
L. kalmii L. Kalm's Lobelia
L. spicata Lam. Pale-spiked Lobelia

COMPOSITAE–Composite Family

Achillea millefolium L. Common Yarrow
Adenocaulon bicolor Hook. Trail-plant
Ambrosia artemisiifolia L. Common Ragweed
A. psilostachya DC. Western Ragweed
A. trifida L. Giant Ragweed
Anaphalis margaritacea (L.) Benth. & Hook. Pearly Everlasting
Antennaria neglecta Greene Field Pussy-toes
A. plantaginifolia (L.) Richards Plantain-leaved Pussy-toes
**Anthemis arvensis* L. Dog Fennel, Field Camomile
**Arctium lappa* L. Great Burdock
Arnica cordifolia Hook. Arnica
**Artemisia absinthinum* L. Wormwood
**A. biennis* Willd. Biennial Wormwood
A. campestris L. Canada Wormwood
A. caudata Michx. Beach Wormwood
**A. ludoviciana* Nutt. White Sage, Mugwort
**A. stelleriana* Besser Seaside Wormwood
Aster ciliolatus Lindl. Lindley's Aster
A. lateriflorus (L.) Britt. White Woodland Aster, Calico Aster
A. lucidulus (Gray) Wieg. Glossy-leaved Aster
A. macrophyllus L. Large-leaved Aster
A. modestus Lindl. Modest Aster
A. prenanthoides Muhl. Crooked-stemmed Aster
A. ptarmicoides (Nees) T. & G. Stiff Aster
A. pubentior Cronq. Northern Flat-topped Aster
A. puniceus L. Purple-stemmed Aster, Swamp Aster
A. sagittifolius Willd. Arrow-leaved Aster
A. sericeus Vent. Silky Aster
A. simplex Willd. Panicled Aster, Tall White Aster
A. tradescanti L. Tradescant's Aster
A. umbellatus Mill. Flat-topped Aster
Bidens beckii Torr. Water-marigold
B. cernua L. Nodding Bur-marigold
B. coronata (L.) Britt. Tickseed-sunflower
B. tripartita L. Swamp Tickseed
**Centaurea cyanus* L. Bachelor's Button
**C. dubia* Suter Star-thistle
**C. jacea* L. Brown Knapweed
**C. maculosa* Lam. Spotted Knapweed
**C. macrocephala* Puschk. Knapweed
**C. nigra* L. Black Knapweed
**Chrysanthemum balsamita* L. Costmary
**C. leucanthemum* L. Ox-eye Daisy
**C. parthenium* (L.) Bernh. Feverfew
**Cichorium intybus* L. Chicory
**Cirsium arvense* (L.) Scop. Canada Thistle
C. muticum Michx. Swamp Thistle
**C. palustre* (L.) Scop. Water Thistle
**C. vulgare* (Savil) Tenore Bull Thistle
Conyza canadensis (L.) Cronq. Horseweed
**Echinacea pallida* Nutt. Purple Coneflower
Erigeron acris L. Bitter Fleabane
E. annuus (L.) Pers. Daisy-fleabane
E. hyssopifolius Michx. Hyssop-leaved Fleabane
E. philadelphicus L. Philadelphia Fleabane, Dairy Fleabane
E. strigosus Muhl. Narrow-leaved Fleabane

Eupatorium maculatum L. Joe-pye Weed
E. perfoliatum L. Boneset
Gnaphalium macounii Greene Winged Cudweed
G. uliginosum L. Low Cudweed
**Helianthus giganteus* L. Tall Sunflower
**H. laetiflorus* Pers. Prairie Sunflower
**H. maximiliani* Schrad. Maximilian's Sunflower
Heliopsis helianthoides (L.) Sweet Ox-eye
**Hieracium aurantiacum* L. Tawny Hawkweed
H. canadense Michx. Canada Hawkweed
**H. florentinum* All. Yellow Hawkweed
H. ×grohii Lepage Hawkweed
H. scabrum Michx. Rough Hawkweed .
H. umbellatum L. Narrow-leaved Hawkweed
Krigia biflora (Walt.) Blake Dwarf Dandelion
Lactuca biennis (Moench) Fern. Tall Blue Lettuce
L. canadensis L. Yellow Wild Lettuce
**Lapsana communis* L. Nipplewort
Liatris cylindracea Michx. Cylindric Blazing-star
**L. novae-angliae* (Lunell) Shinners New England Blazing-star
**Matricaria chamomilla* L. Wild Camomile
**M. matricarioides* (Less.) Porter Pineapple-weed
**Parthenium integrifolium* L. Wild Quinine
Petasites frigidus (L.) Fries Sweet Coltsfoot
Prenanthes alba L. White-lettuce, Lion's Paw
P. racemosa Michx. Swamp Rattlesnake-root
**Ratibida pinnata* (Vent.) Barnh. Prairie Coneflower
Rudbeckia hirta L. Black-eyed Susan
Senecio aureus L. Golden Ragwort
S. indecorus Greene Northern Ragwort
Solidago altissima L. Tall Goldenrod
S. bicolor L. White Goldenrod
S. canadensis L. Canada Goldenrod
S. flexicaulis L. Zigzag or Broad-leaved Goldenrod
S. gigantea Ait. Giant or Late Goldenrod
S. graminifolia (L.) Salisb. Grass-leaved Goldenrod
S. hispida Muhl. Goldenrod
S. juncea Ait. Early Goldenrod
S. nemoralis Ait. Gray Goldenrod
S. spathulata DC. ssp. *gillmanii* (Gray) Cronq. Deam's Goldenrod
S. spathulata DC. ssp. *randii* (Porter) Cronq. Rand's Goldenrod
S. speciosa Nutt. Showy Goldenrod
S. rugosa Ait. Rough-leaved Goldenrod
S. uliginosa Nutt. Bog Goldenrod
Senecio pauperculus Michx. Balsam Ragwort
S. plattensis Nutt. Prairie Ragwort
**S. sylvaticus* L. Wood Groundsel
**Sonchus arvensis* L. Field Sow-thistle
**S. asper* (L.) Hill Spiny-leaved Sow-thistle
**S. oleraceus* L. Common Sow-thistle
**S. uliginosus* Bieb. Smooth Sow-thistle
**Tanacetum vulgare* L. Tansy
**Taraxacum laevigatum* (Willd.) DC. Red-seeded Dandelion
**T. officinale* Weber Common Dandelion
**Tragopogon dubius* Scop. Pale Yellow Goat's Beard
**T. porrifolius* L. Salsify, Purple Goat's Beard
**T. pratensis* L. Dark Yellow Goat's Beard

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TURION FORMATION AND GERMINATION IN *MYRIOPHYLLUM VERTICILLATUM*: PHENOLOGY AND ITS INTERPRETATION[1]

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Some aquatic vascular plants produce specialized buds which are important both in vegetative reproduction and in the survival of the species through periods of stress, e.g., winter in the north temperate region. These buds have been called winter-buds, turions, resting buds, and hibernacula. We have chosen to use the term turion as defined by Glück (1906), i.e., a distinctive vegetative bud which functions as a propagule and as an overwintering device in certain aquatic vascular plants. For a further discussion of the term see Weber (1973).

These specialized buds are similar to the dormant buds of terrestrial plants in that they serve as a means of surviving periods of unfavorable

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Fig. 1. Vegetative shoot of *M. verticillatum.*

conditions for growth. However, unlike most buds of terrestrial plants, turions also act as propagules and in some species may be the major means of reproduction (Weber, 1972). For these reasons turions are interesting subjects for study.

We chose to study the development and germination of the turions of one of the water-milfoils, *Myriophyllum verticillatum* L. This submerged vascular hydrophyte occurs singly or in large colonies. Like many species of the genus, *M. verticillatum* grows rapidly and may be considered a weed in some areas. The plant is generally sparsely branched and has a whorl of four pinnately divided leaves at each node (Fig. 1).

It is our purpose to describe the phenology of turion development and germination in this species. Furthermore, we wish to show that phenological studies can lead to valuable insights into the physiological factors which control the observed development. Thus, a knowledge of plant physiology can open up a very interesting perspective of natural history. The observations reported here were made in conjunction with, and provided a basis for, laboratory study of the environmental and hormonal control of turion development and germination.

MATERIALS AND METHODS

Most of the study was conducted in the west end of Hiland Lake (Washtenaw and Livingston cos., Mich.) because *M. verticillatum* is abundant there. The lake, which is a reservoir on Portage Creek at Hell, Michigan, has a maximum depth of about 4 m; it is less than 3 m deep at the west end. Some investigations were also conducted at Crooked Lake (Washtenaw Co., Mich.), which has a maximum depth of about 12 m; however, plants were found only down to about 6 m.

Observations on the plants were recorded over a period of three years (1971-1973). From March or April, when the lake became essentially free of ice, to August, observations were made at least monthly and usually every two weeks. During the fall, i.e., September through November, the lake was visited weekly or more often. During the winter, observation was possible only when safe ice was present. No attempt was made to determine quantitatively the distribution and population density of the plants and turions.

Collections were made by hand whenever possible; however, a grappling hook and a long-handled (4-10 ft.) three-prong rake were also used. When the lake was free of ice observations were made from a small boat. In the winter, collections were obtained through a hole in the ice using the long-handled rake.

In order to determine the origin, e.g., seed or turion, of the plants the basal part of intact plants was examined for the presence of a U-shaped base. The criteria for determining that the base was intact were the presence of roots and the absence of a fresh break at the base of the stem. Fresh wounds differ from old ones in that the former are green, whereas the latter are brown to black. Observations were also made on plants which had been uprooted by other users of the lake.

On each occasion when the plants were studied, data concerning the general appearance of the plants and the stage of turion development were recorded. The former included: 1) the size of the plants and area covered by the population with emphasis on locating high density areas, 2) the health of the plants, i.e., green and apparently active, or turning brown and decaying, and 3) the period of flowering and fruiting. Stages noted in turion development included: 1) the advent of turion formation, 2) the size of buds and turions, and 3) the attachment of the turions to the parent plant. Each day that collections were made, water temperature was sampled with a standard laboratory thermometer held 30-60 cm below the surface of the water until it equilibrated. One reading was taken per day, generally between 10:00 am and 4:00 pm. While these data do not provide a detailed picture of temperature change, they do show the trend in temperature through the season. Daylength was estimated from the Smithsonian Meteorological Tables (1968).

Finally, cross-sections of the stems of turions and actively growing plants were studied under the microscope to compare the relative size of the air space in the stem.

RESULTS AND DISCUSSION

The first problem encountered was the positive identification of the species chosen for study. Both *M. verticillatum* and *M. exalbescens* Fernald, which are difficult to distinguish except by their inflorescences, occur in Hiland Lake, but fortunately, three vegetative characteristics were found to be helpful in distinguishing these species. First, the turions of *M. verticillatum* are club-shaped with leaves very similar to normal leaves, whereas *M. exalbescens*

Fig. 2. Turion attached to vegetative shoot.

produces a slender, cylindrical turion with leaves much smaller than the normal leaves (Weber, 1972). The difference in the size and morphology of the turion leaves can also be diagnostic when these leaves are present on mature plants. Second, the vegetative leaves of *M. exalbescens* have a rougher texture than *M. verticillatum.* Furthermore, the normal vegetative leaves of the former appear somewhat greyish, while those of the latter are quite green. Third, the internodes of *M. verticillatum* are shorter (generally less than 1 cm long except near the base) than those of *M. exalbescens,* which are about 2 cm long. The last two characteristics may not be well developed in all lakes.

Turions may begin forming as early as late September and continue to form through the beginning of November. The earliest sign of turion formation is the enlargement of the vegetative buds, both terminal and axillary. When the bud has grown to 3-4 mm long and about 2 mm wide, it begins to assume the club-shaped appearance of a turion. At maturity these turions are generally 20-50 mm long and 4-8 mm wide (Fig. 2).

The importance of temperature in turion induction is emphasized by the data of Fig. 3. In 1972 there was a particularly cold fall with the water temperature dropping from 19°C on September 20 to 13°C on October 9. During the same period in 1971, the temperature was at or above 20°C. This early decrease in water temperature in the fall of 1972 coincided with an early development of turions: abundant turions on rooted plants by October 9, 1972, compared with abundant turions by October 28, 1971. In 1973, abundant turions did not appear on rooted plants until early November, when water temperature finally declined below 15°C. Thus changes in water temperature influence turion formation.

Although temperature has been implicated as a controlling factor,

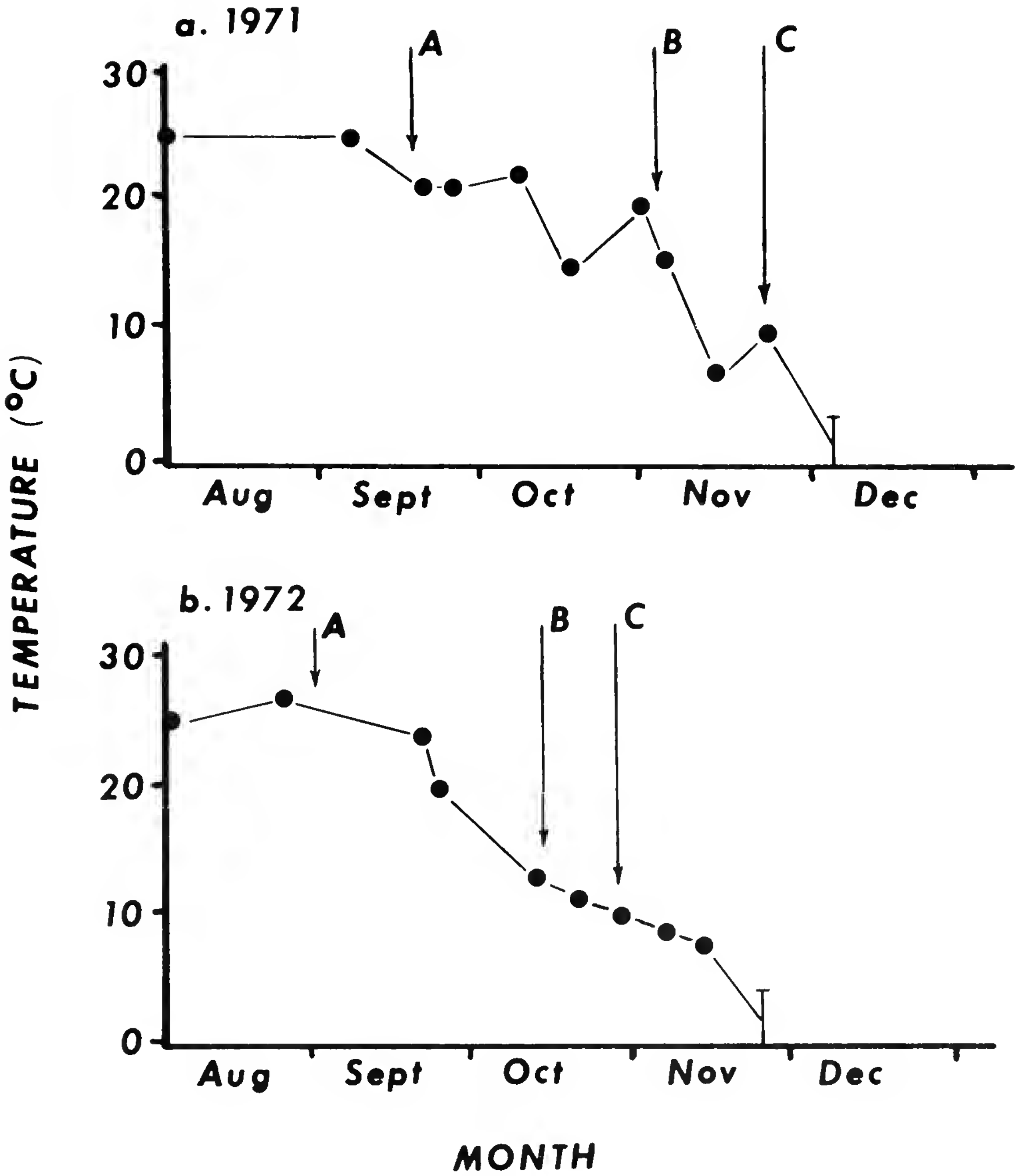

Fig. 3. Turion development in relation to changes in the water temperature at 30-60 cm below the surface in Hiland Lake during late summer and fall. a: 1971. b: 1972. (A: Turions developing on floating plants. B: Turions developing on all rooted plants. C: Turions abscising.)

daylength could also be important in turion induction, as it is for induction of dormant buds in trees (Naylor, 1961). Indeed, Bowman (1923) found that plants of *M. verticillatum* maintained at a constant temperature of 15-18°C formed turions only after the daylength had decreased to 10 hr or less, i.e., November. He concluded that turion induction is under photoperiodic control. (Note: Bowman thought he was studying *M. spicatum.* However, the turions pictured in Plate XXVII of his paper appear to be those of *M. verticillatum.*) Except for the fact that rooted plants of *M. verticillatum* formed turions only in the fall, when the daylength is less than 12 hr, our field studies provide no direct evidence to confirm or deny the importance of photoperiod in turion induction, and if anything, they suggest that temperature may be more important.

Three additional factors, i.e., plant size, water depth, and light intensity, appear to have no noticeable influence on turion development. Plants no more than 10 cm long form turions at the same time as plants 3 m long. Similarly, turions develop at the same time on plants at different depths. Finally, because light intensity decreases rapidly with depth, light intensity does not appear to be a factor in turion induction for plants in the field.

Goebel (1893) proposed that a decline in mineral nutrients dissolved in the water induced turion development in *M. verticillatum* in nature. However, Bristow and Whitcombe (1971) have shown that vascular hydrophytes can absorb a substantial amount of phosphate, and presumably other needed minerals, through their roots. Since the mineral supply in the substrate is unlikely to change seasonally, it appears that mineral nutrient deficiency is not a factor in the induction of turions on rooted plants in the field.

When the turions are mature, they abscise from the parent plant, generally beginning in November. Sometimes they detach along with several internodes of the parental shoot. These internodes act as a float and allow for some dispersal in the lake before the turions abscise from this tissue. The entire parental plant decays after most or all the turions have abscised. A few turions may remain attached to the decaying base of the parent plant. The abscised turions sink to the substrate where they remain quiescent until about February when germination begins.

The process of germination can be divided into three parts: 1) the spreading of the leaves, starting at the basal end, 2) the elongation and curving of the axis, and 3) the formation of roots at the base of the U formed by the curving axis (Fig. 4). After germination is well along, the air space in the stem enlarges, causing the stem to increase in diameter, for example, from 1-2 mm in the turion to about 5 mm. This enlargement of the air space causes the young shoot to be buoyed up in a vertical position. In fact, mature rooted plants are vertical or trailing near the surface, and the whole plant will float at the surface if uprooted. Generally, the roots form and anchor the plant before

Fig. 4. Germinating turion. Note root at arrow.

the young shoot becomes less dense than the surrounding water. In the spring, the unanchored turions float to the surface and are washed onto shore where they die, except for the infrequent occasion when they land on water-logged soil where they may form new plants (Glück, 1906).

The fact that turions do not germinate in October when the conditions seem more favorable than in February indicates that they are dormant during the fall. At the time of germination, the water temperature is 0-4°C; in fact, germination often occurs beneath a layer of ice and snow. Since many dormant buds require a cold treatment to break dormancy (Wareing, 1969), it is possible that the cold breaks an innate dormancy.

Our field studies did not indicate whether or not daylength, which is about 10 hr in February, is important in germination; however, Bowman (1923) presents evidence that, at least under the conditions he studied, photoperiod is important in germination.

Turions appear to be very important in the propagation of *M. verticillatum.* Although exact figures were not obtained, nearly all plants collected with intact bases had the characteristic U-shape of plants which developed from turions. This type of base is reminiscent of turions in other ways: the lower leaves resemble turion leaves in that they are stiffer than normal leaves, all of the roots are adventitious even in young plants, and the basal end of the stem is truncate rather than tapered or root-like. During the growing season plants can also develop from buried shoots. These plants are found in shallow areas during the summer and fall; however, no buried shoots were found in the winter. In fact, besides turions, only decaying parts of plants were found during the winter.

An interesting situation exists in relation to shoots and plants which are free-floating, i.e., not rooted in the substrate. Both plants which have been uprooted and detached shoots form turions much earlier than rooted plants (Fig. 3). Because plants which are rooted in shallow water with much of their stems trailing at the surface form turions at the same time as other rooted plants, it can be concluded that the detachment of the roots from the substrate is critical. The effect of detachment could be in part a response to mineral nutrient deficiency similar to that found by Goebel (1893).

A final observation on floating plants is that they eventually become denser than water. The increase in density begins at the morphological apex of the stem and progresses toward the base. Coincident with the increase in density is the production of adventitious roots. When the tip of the shoot makes contact with the substrate the roots anchor the shoot and a new plant develops.

SUMMARY

Fig. 5 summarizes our observations on the seasonal progression of turion induction and germination in *M. verticillatum.* Both daylength and temperature are decreasing during turion formation. Moreover, turions do not form until the water temperature has dropped below about 15°C. Over a substantial range, the size of the plant, the depth at which it grows, and the light intensity all appear to be unimportant in induction. However, attachment to the substrate by roots is very important. Germination occurs after a dormant period at 0-4°C and during a period of increasing daylength. It is

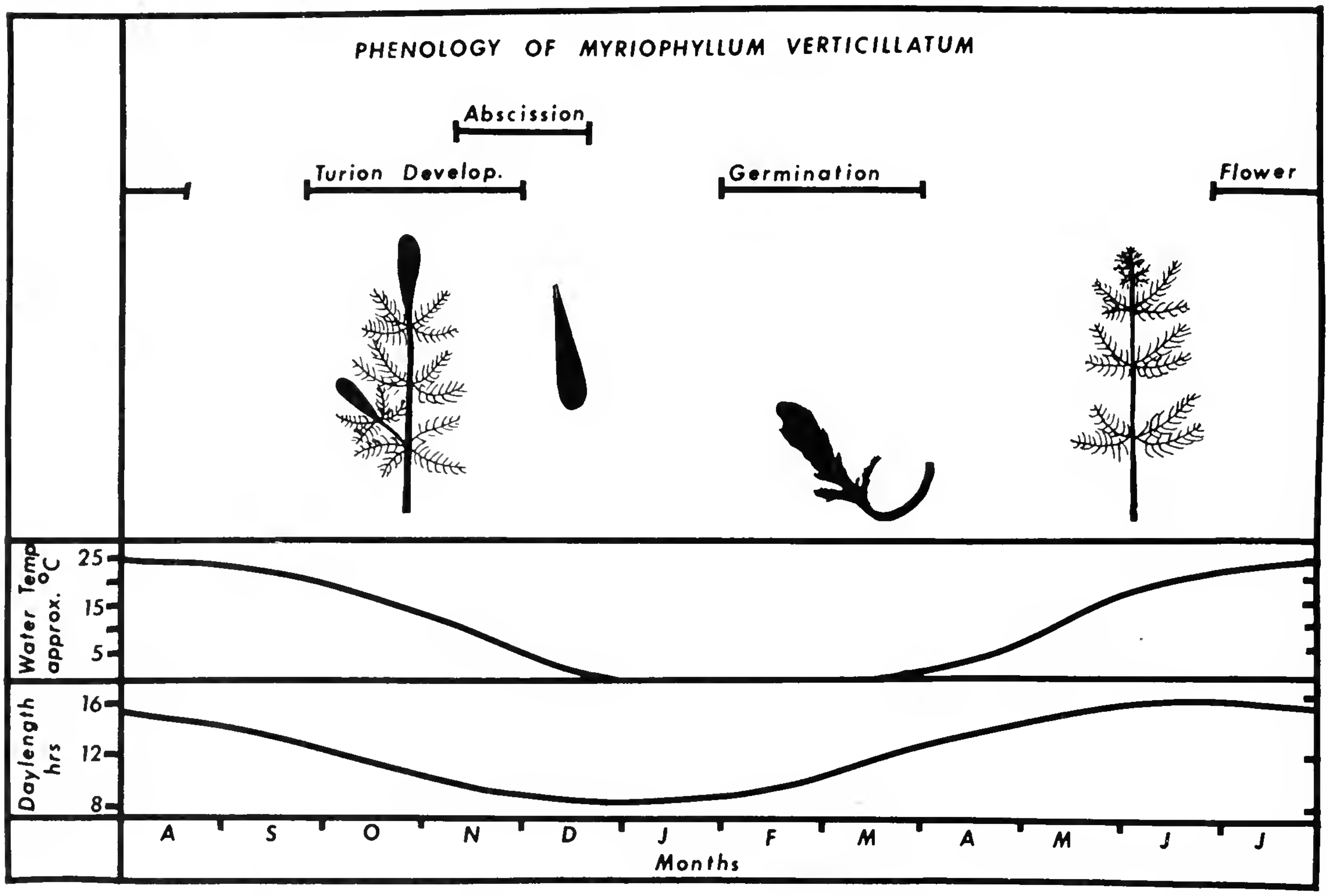

Fig. 5. Phenology of *Myriophyllum verticillatum,* with emphasis on turion formation and germination. (The horizontal bars indicate important periods in the development of the plant. Dates are approximate. The temperature curve is derived from field data. The daylength curve is based on Smithsonian Meterological Tables (1968).)

proposed that turion induction and germination are controlled by water temperature and possibly daylength. The production of turions is important for the propagation of this species. Plants floating at the surface and not attached to the substrate produce turions much earlier than rooted plants. Furthermore, rooting of the apices of floating plants provides another means of vegetative propagation for this species.

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EURASIAN WATER-MILFOIL IN MICHIGAN[1]

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HISTORY OF INVASION

Myriophyllum spicatum L., a submersed aquatic plant native to Eurasia, has found its way into the waters of Michigan. Prodigious growth of this plant, relative to native species, provides the Great Lakes states with a problem of considerable economic importance. The unusual feature of the growth of Eurasian water-milfoil in our lakes is its ability to reach the surface while rooted in three to five meters (approximately 10 to 16.5 feet) of water. It thus overgrows submersed native species. The density of a stand is sufficient to render the water from shore to this depth visually obnoxious and useless for recreation.

M. spicatum was apparently introduced to this country in the Chesapeake Bay region late in the 19th century (Holm, Weldon, & Blackburn, 1969). It was first collected from the Bay in 1902 (Nichols & Mori, 1971). Its abundance there did not constitute a nuisance until late in the 1950's. In 1960, approximately 20,000 hectares (1 hectare equals 2.47 acres) of tidewater were extensively overgrown; in 1962, the plant extended to 40,000 ha. and in 1963, at the height of its infestation, it covered nearly 80,000 ha. (Bayley, Rabin, & Southwick, 1968). During this time, the species was spreading from this region to the north and south. The rapidity of the plant's invasion is illustrated by data from Currituck Sound, North Carolina (Crowell, Steenis, & Sincock, 1967). It was first reported from this area in 1965 when approximately 40 ha. were infested. A year later, it was a severe problem in 3200 ha. and was established in an additional 27,000 ha. The distribution map for the species by Reed (1970) shows that *M. spicatum* now has a continuous distribution from Chesapeake Bay north through the Hudson River valley to the St. Lawrence River valley, and west along the lower Great Lakes to southern Michigan. This northwest extension of the range from Chesapeake Bay continues westward from Michigan through northern Indiana and Illinois to southern Wisconsin, but not beyond. Reed's pattern of distribution may indicate the principal corridor along which the plant was dispersed from

[1]The substance of this paper was presented at the 77th Annual Meeting of the Michigan Academy of Science, Arts, and Letters, Ann Arbor, Michigan, April 5-7, 1973. The study was sponsored by the Michigan Agricultural Experiment Station and this paper is Journal Article No. 6381.

Chesapeake Bay to our region, or it may be an artifact of the process by which information was collected for preparation of the map.

M. spicatum arrived in the Michigan area some times prior to 1962. In that year, Steenis collected the plant at a site in Steuben County, Indiana (Hotchkiss, personal communication to E. G. Voss). This county is adjacent to the southern border of Michigan. Reed (1970) apparently extended the range of the plant into southern Michigan on the basis of the observation of Steenis. It was our purpose to begin to document the occurrence of *M. spicatum* in Michigan and to describe the general features of an infestation.

RECORDS FOR MICHIGAN

Differences in the taxonomic treatment of *M. spicatum* made recognition of the species difficult during the early years of its invasion into Michigan. The plant's floral and vegetative features closely resemble those of our common temperate zone species, *M. exalbescens.* The two species differ principally in the number of paired subdivisions of the leaf: *M. spicatum* has 14-21 pairs, while the native plant has 6-11 pairs. Some authors have treated *M. exalbescens* as a variety or subspecies of *M. spicatum,* and many manuals have not recognized both native American and introduced Eurasian taxa as occurring in North America.

The first collection of *M. spicatum* in Michigan of which we are aware is a specimen collected in Whitmore Lake, Washtenaw County, by Melinda Denton in 1965. It is now in the herbarium of Michigan State University. In accord with the practice at the time, it was called *M. exalbescens.* E. G. Voss collected additional material from the same lake in 1970 and it was confirmed as *M. spicatum* by Steenis and Uhler (material in the herbarium of the University of Michigan). Our collections in the summers of 1972 and 1973 confirmed the occurrence of *M. spicatum* in the counties of Michigan shown in Figure 1. Many of the specimens were obtained through a well advertised program for the identification of nuisance aquatic plants that was administered by the office of the MSU Extension director in each county. Others were obtained while responding to citizens' requests to evaluate nuisance plant conditions on lakes, flowages, and ponds. Since specimens from the Lower Peninsula were taken from a wide variety of habitats, and since the plant occurred at high density in these, it is likely that the species has a broader distribution in the Lower Peninsula than is shown in Figure 1. Workshops on the identification and control of nuisance aquatic plants were held for Extension directors in the counties of the Upper Peninsula in 1972. They were alerted to the potential of a problem with *M. spicatum* at that time. To date, collections by Extension personnel and ourselves in the Upper Peninsula have included *M. spicatum* from only one site: Little Bay de Noc near Escanaba.

A CASE STUDY

Among the 1972 reports of impairment of water use by *M. spicatum* was the case of Budd Lake in Clare County. This seepage lake occupies a basin in the calcareous morainic materials of central Lower Michigan. It has a

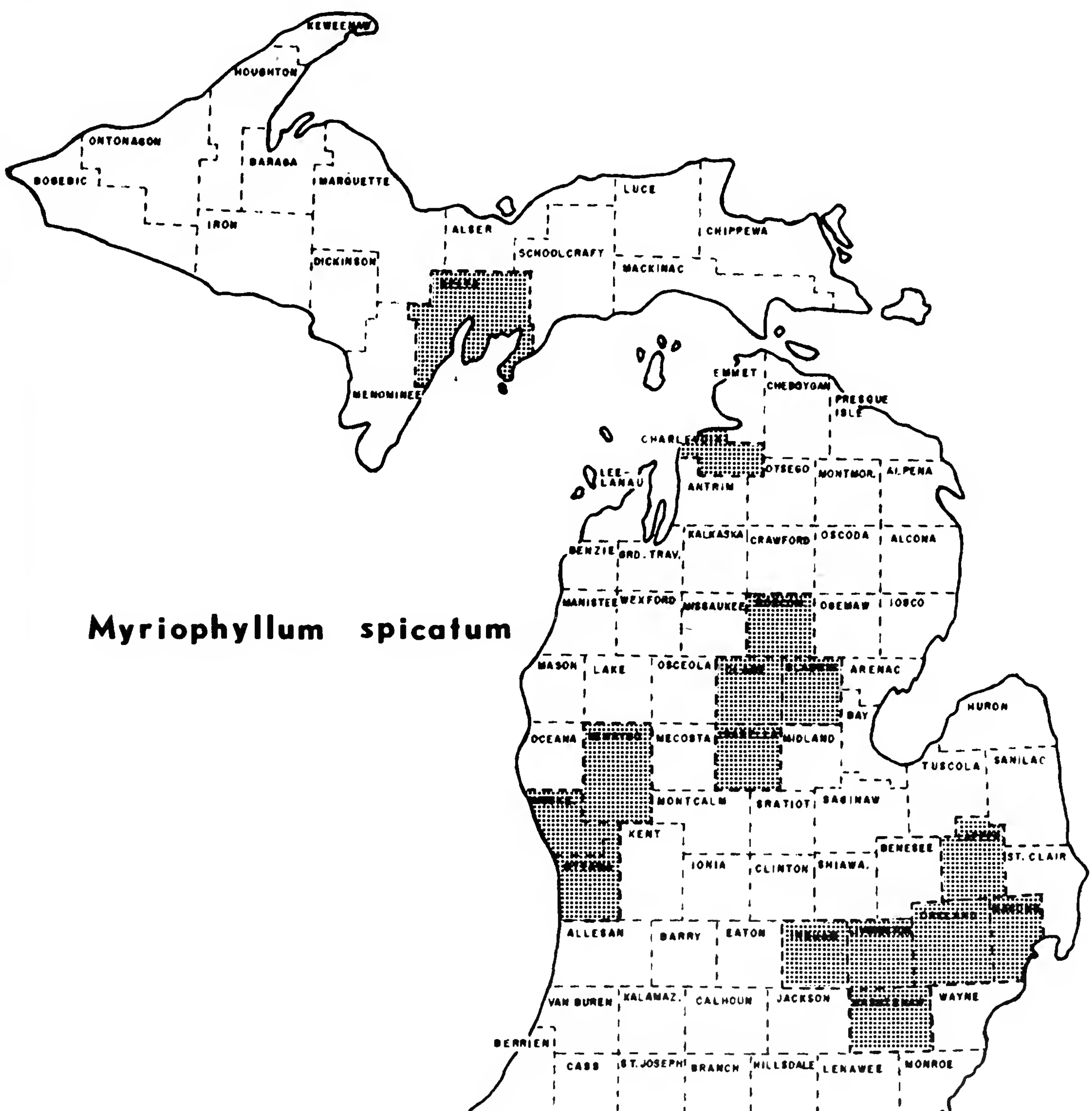

Fig. 1. Counties of Michigan in which the occurrence of Eurasian water-milfoil was confirmed in 1972 and 1973.

surface area of approximately 70 ha. Local residents had noted a gradual increase in native aquatic plant production over the past decade, and in 1972 completed a system of sanitary sewers to decrease the quantity of nutrients entering the lake. The Eurasian water-milfoil population exploded during that growing season to cover nearly a fifth of the surface of the lake. The pattern of distribution is shown in Figure 2. The infestation was confined to depths within the 6-meter contour and seemed to be advancing from north to south in the basin.

A series of transects, each 60 meters long, was established in the lake at positions shown in Figure 2. The names and heights of all species occurring along the transects were recorded. Profiles thus obtained for three of the

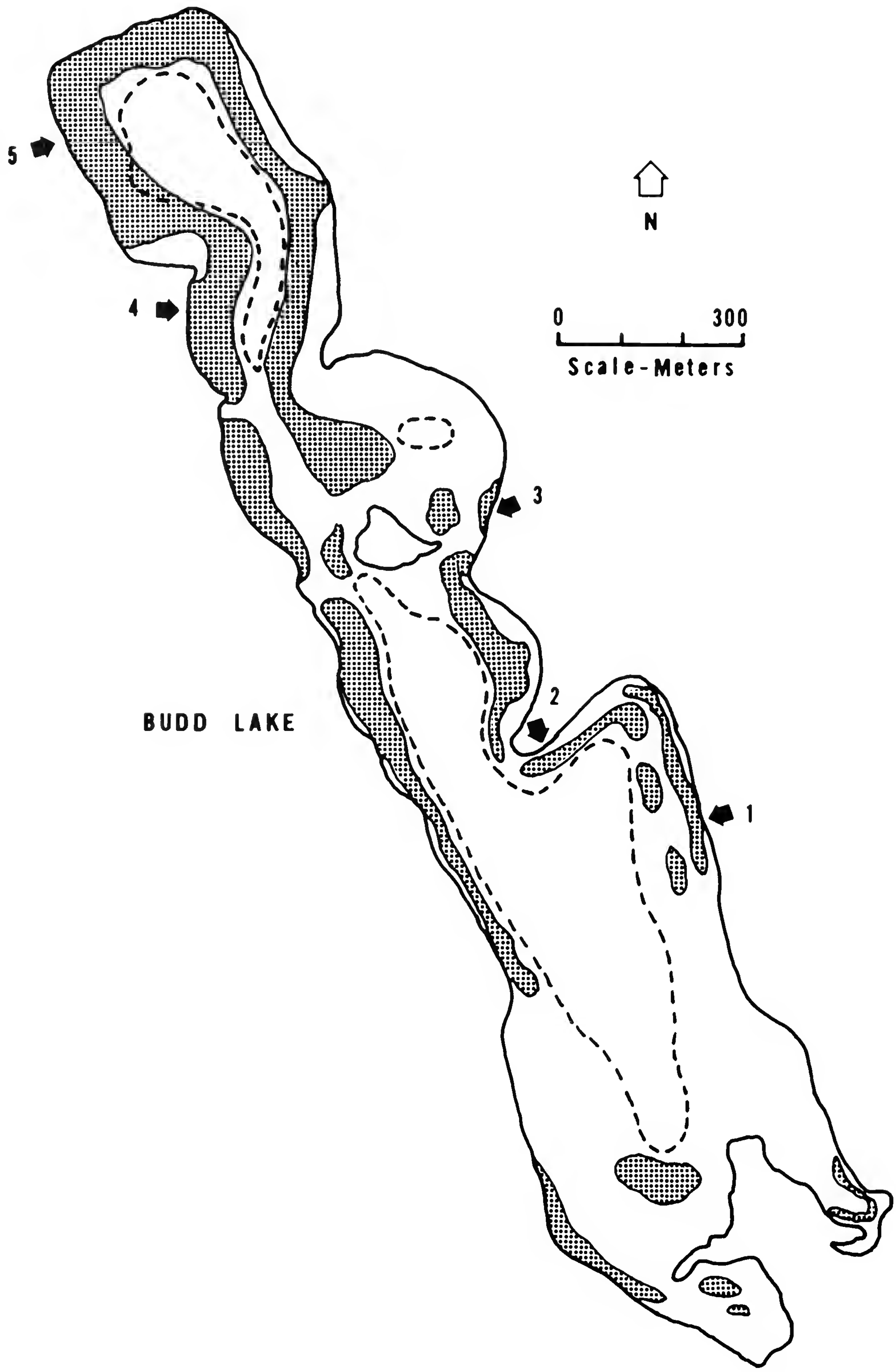

Fig. 2. The distribution of *Myriophyllum spicatum* (stippled areas) in Budd Lake, Clare County, Michigan, October of 1972. The six-meter contour of the basin is shown by the dashed line; positions of transects are numbered adjacent to the arrows. (The distribution of *M. spicatum* based on materials provided by courtesy of the Budd Lake Association).

transects are presented in Figure 3 as illustrative of the aspect of the communities of the lake.

Native vegetation, dominated by *Vallisneria americana* and a species of *Chara,* was being invaded by clones of *M. spicatum* along Transect 1 in the southeastern portion of the lake. Vegetative fragments of Eurasian water-milfoil were rooting through the canopy of the tightly packed *Chara* meadow and between the upright rosettes of *V. americana.* Along portions of the transect where older plants of water-milfoil existed, *Chara* was largely absent.

Transect 4 had an aspect that was typical of heavily infested shorelines having a gradual slope. *M. spicatum* rooted in the bottom reached the surface from depths as great as 3.5 meters, and existed down to slightly more than 5 meters. The low-growing native community was represented except for *Chara.* Transect 5 was typical for areas of heavy infestation where the slope of the basin dropped quickly from the shore. Eurasian water-milfoil was poorly established on the steep slope and *Chara* occurred with other native species. Gaps in the distribution shown in Figure 2 along the northeast and southwest shores of Budd Lake and in the vicinity of Transect 2 are explained by the apparent inability of *M. spicatum* to become well established on steep slopes at this stage of the infestation. In the deep along Transect 5, Eurasian water-milfoil reached the surface from a depth of 3.5 meters and existed down to 5 meters. Transects 4 and 5 show that *V. americana* persisted to a depth of approximately 4 meters under the canopy of *M. spicatum.*

DISCUSSION

Nichols and Mori (1971) in their detailed description of the vegetation of Lake Wingra have documented the dominance of *M. spicatum,* which now overgrows the native submersed flora. Water-milfoil stands in depths less than 2.4 meters averaged 253 stems/m^2 and a standing crop of 385 gm dry wt/m^2. Density decreased below 2.4 meters in Lake Wingra to 70 stems/m^2 and an average standing crop of 142 gm dry wt/m^2. Among the species present, *M. spicatum* colonized the deepest portions of the littoral zone as in Budd Lake. While the biomass of Eurasian water-milfoil in the Lake Wingra stands is impressive, it falls short of maxima for submersed species reported in the literature—for example, 1950 gm/m^2 for *Najas guadalupensis* and 1116 gm/m^2 for *Ceratophyllum demersum* (Odum, 1957). Nichols (1971) found an average production rate of 6.1 gm dry wt/m^2/day (53 lbs/A/day) for the growth interval from mid-June to mid-July in nuisance-density stands on Lake Mendota, Wisconsin. This rate is not exceptionally high for submersed plants and might be expected for native species (McNabb, Tierney, & Kosek, 1972). The competitive advantage of *M. spicatum* may not be explained by an exceptional growth rate once a stand is established, but rather by (1) over-wintering a relatively large viable vegetative biomass that holds the space for the stand from year to year and (2) an efficient means for dispersing and colonizing new areas of a lake. The first of these is consistent with our observations of over-wintering in experimental ponds on the Michigan State University campus and in Budd Lake. It appears to be confirmed in the

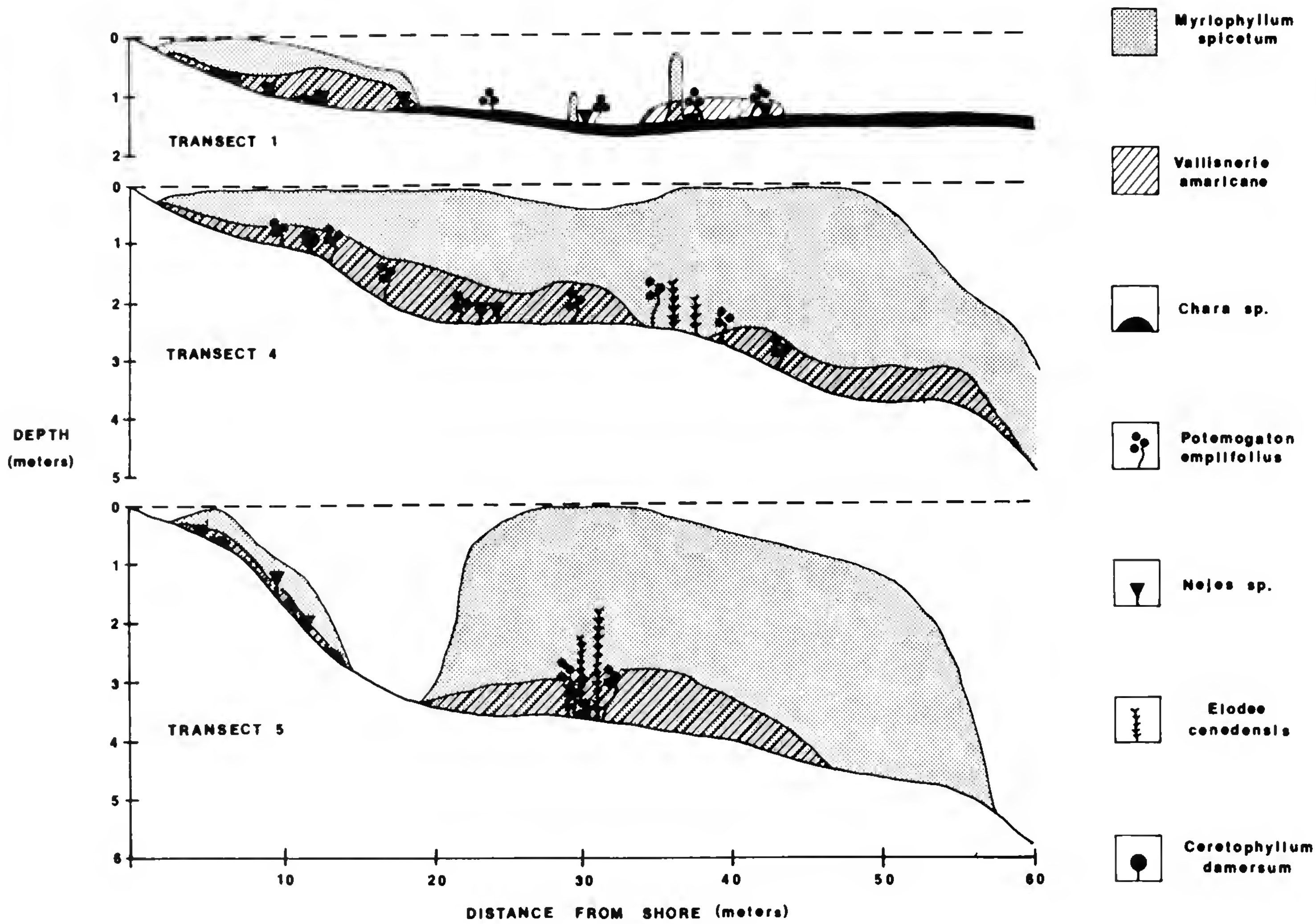

Fig. 3. The physiognomy of plant communities along transects 1, 4, and 5 in Budd Lake, August, 1972.

annual standing crop data of Nichols (1971). From observations on the rate of spread of the plant in the reservoirs of the TVA system, Stanley (reported by Smith, 1971) calculated that in one year one fragment could propagate nearly 250 million new fragments. The rate of spread in the TVA system and elsewhere has been sufficiently astonishing to consider the plant truly exceptional in its ability to occupy new sites.

Some measure of successful control of Eurasian water-milfoil has been accomplished in this country with cutting and harvesting, water drawdown, and herbicides. Nichols' (1971) comprehensive analysis of cutting showed one or two harvests per year can result in satisfactory control. This is the method of control used on the Madison, Wisconsin, lakes and on Pine Lake of Oakland County, Michigan. Wintertime water level drawdown on the TVA system kills all of the plants on well drained shorelines (Smith, 1971). Infestations are not eliminated by this procedure since reservoir operation for multiple uses fixes the minimum water levels above depths to which this species can grow. Whereas a variety of liquid formulations of herbicides can be used to control *M. spicatum* in shallow water, low volatile ester formulations of 2,4-D in granules are the herbicides of choice for deep growing clones (Smith, 1971). Smith and Isom (1967) conclude from their data that large-scale application of 2,4-D for Eurasian water-milfoil control on TVA reservoirs has not produced adverse effects on aquatic fauna and water quality.

Bayley, Rabin, and Southwick (1968) have demonstrated that the dramatic 95% decline of *M. spicatum* in Chesapeake Bay between 1965 and 1967 was associated with a virus-like disease in the population. This natural agent of control may eventually alleviate a portion of the problem caused by the plant in Michigan waters. However, the disease does not appear to have followed rapidly on the heels of freshwater infestations elsewhere in the country.

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Reviews

MOSSES OF THE GREAT LAKES FOREST. By Howard Crum. Contributions from the University of Michigan Herbarium Vol. 10. 1973. 404 pp. $6.00 [+$.50 postage].

This book is a welcome addition to the literature covering bryophytes of eastern North America. As expected in a manual, good keys are provided with adequate descriptions and suitable line drawings, along with ecological and geographic data including exact stations where species have been found in Emmet, Cheboygan, Mackinac, and Presque Isle counties of Michigan. Chromosome numbers where known are added. Brief notes on related species in adjacent areas are included. Where pertinent, references which include synonyms are made to the manuals of Conard, Grout, and Jennings.

It is more than a manual including valuable, interesting, and sometimes extensive discussions of such diverse subjects as the ecology, evolution, number of spores in capsule, uses by man and in nature, edibility and also poisonous nature, of some species of mosses. Many literary quotations add much to the delight of the reader.

The only major criticism that can be made of the book is the lack of scale or degree of magnification of the illustrations; of course, one can refer to the text description for size. Beginners find the generic key easier to use, if the second 2 (p. 3) reads "Costa not lamellose, or the leaf ecostate." On page 14, the first 154 should read "Leaves" instead of "Leaf-cells," and the first 155 should indicate that *Leucodon* may have leaves without plications as noted on page 211. Rhizoids on page 51 are described as "non-living" although they have been known to give rise to new leafy gametophytes. Minor inconsistencies occasionally appear: *Paludella* is included in the key but reported only from an adjacent area; *Hyophila* is reported from essentially the same location but is not in the key. For a publication of this size the errors are remarkably few and minor.

A class in Bryology at The University of Tennessee, Knoxville, has already used the book with success. Since about 80% of the Southern Appalachian species of mosses are represented, the keys and descriptions, including illustrations, are as useful as, or more useful than, those in any other publication available.

At the end is a very complete glossary followed by a very comprehensive bibliography including many diverse and interesting facets of bryology. It is terminated by an index divided into two parts: a short one devoted to subjects other than taxonomy, and a longer taxonomic one.

The book is extremely useful for students and professional bryologists, and no respectable biological or botanical library should be without it.

—Aaron J. Sharp

LEGUMINOSAE OF THE UNITED STATES: I. Subfamily Mimosoideae. By Duane Isaly. Memoirs of The New York Botanical Garden Vol. 24, No. 1. 1973. 152 pp. $7.00.

Appearance of this first part of a manual of the Leguminosae of the continental United States "shorn of Alaska" is a major taxonomic event, although locally we realize that almost all species of this subfamily grow only some distance from the Great Lakes region. Let us hope that subsequent parts of the manual, 25 years in preparation, will be promptly forthcoming! Unfortunately, most species are not mapped (and even the 48 maps are not cited in the text), and none are illustrated—making the first-page comparison with Hitchcock's grass manuals a bit inappropriate. But there are descriptions and full keys, including a useful key based on vegetative characters to genera of U.S. legumes with bipinnate leaves. Differences from many systematic treatises include considerable emphasis on cultivated as well as native and naturalized species, and relegation of most synonymy to an "Annotated Index of Names." Every publishing taxonomist should read the five-page introduction for a refreshing example of how traditional stuffiness of expression can be avoided—from the purposeful hope that the manual "will guide the steps of a new generation of taxonomists into intellectual pastures yet untouched" to acknowledgment "of small but continuous doses of fiscal oxygen" from the Iowa Agricultural Experiment Station.

—E. G. V.

Editorial Notes

SUBSCRIPTIONS RISE. As already recorded on the inside front cover, inflation has forced us to increase our income. The costs of printing, paper, and postage are rising dramatically. Effective with Vol. 14 (1975) the annual subscription rate for THE MICHIGAN BOTANIST will be $5.00. (That will be eight years after the previous increase.) Members of the Botanical Club will continue to receive the journal as one of the privileges of membership, but membership dues will also have to rise. Back issues through Vol. 13 will remain at $3.00 per volume, when available. Page charges, for all pages in excess of 10 in any one article, have been raised to $20.00, effective with manuscripts received in February 1973.

Except for the increase in charges for excess pages, the "Information for Authors" printed on p. 142 of the March 1973 issue remains relevant. Prospective authors are urgently requested to study that page. We receive entirely too many manuscripts which fail to doublespace *everything,* which use "erasable" types of paper, which are not provided in duplicate, and/or which do not follow the style of this journal. Such manuscripts will receive relatively low priority for editorial action.

We have been informed that due to cutbacks by the National Weather Service, the State Climatologist's position and office have been closed. The information and climatological data formerly available from that office are now provided through the Michigan Department of Agriculture Weather Service, Steven S. Nisbet Bldg., 2nd Floor, Room 240, 1407 South Harrison Rd., East Lansing, Michigan 48823.

The March number (Vol. 13, No. 2) was mailed March 21, 1974.

Publications of Interest

SPRING FLOWERS OF THE NATIONAL CAPITAL REGION. By John M. Gillett. National Capital Commission, [Ottawa, Ontario, Canada]. 1973. 116 pp. With 52 color photographs, this is an attractive guide to many familiar wildflowers of the Great Lakes region. The pictures are mostly very good—especially for three-color lithography. There is a short description of each plant, with notes on habitat and season. The brief illustrated glossary and the text are bilingual, and might even help some students of the outdoors to learn a bit of French in a pleasant way, should they be deficient in that language!

RARE OR ENDANGERED VASCULAR PLANTS OF NEW JERSEY. By David E. Fairbrothers and Mary Y. Hough. Science Notes No. 14, New Jersey State Museum, Trenton 08625. 1973. 53 pp. A good example of what can be done in a subject of increasing concern to both naturalists and legislators. There is a historical introduction and a useful discussion of working concepts, followed by an annotated list of 190 species. Many of the latter, while considered rare or endangered in New Jersey, are abundant basic elements of vegetation in many or all parts of Michigan; e.g., red pine (*Pinus resinosa),* dwarf birch (*Betula pumila*), squirrel-corn (*Dicentra canadensis*), wormwood (*Artemisia caudata*), bog-rosemary (*Andromeda glaucophylla*), labrador-tea (*Ledum groenlandicum*), cranberry (*Vaccinium oxycoccos*), and Canada violet (*Viola canadensis*).

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(On the cover: Presque Isle River, near its mouth, Porcupine Mountains Wilderness State Park, Gogebic County, Michigan. Photo by Jon Roethele, Michigan Department of Natural Resources. July 1971.)

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THE MICHIGAN BOTANIST

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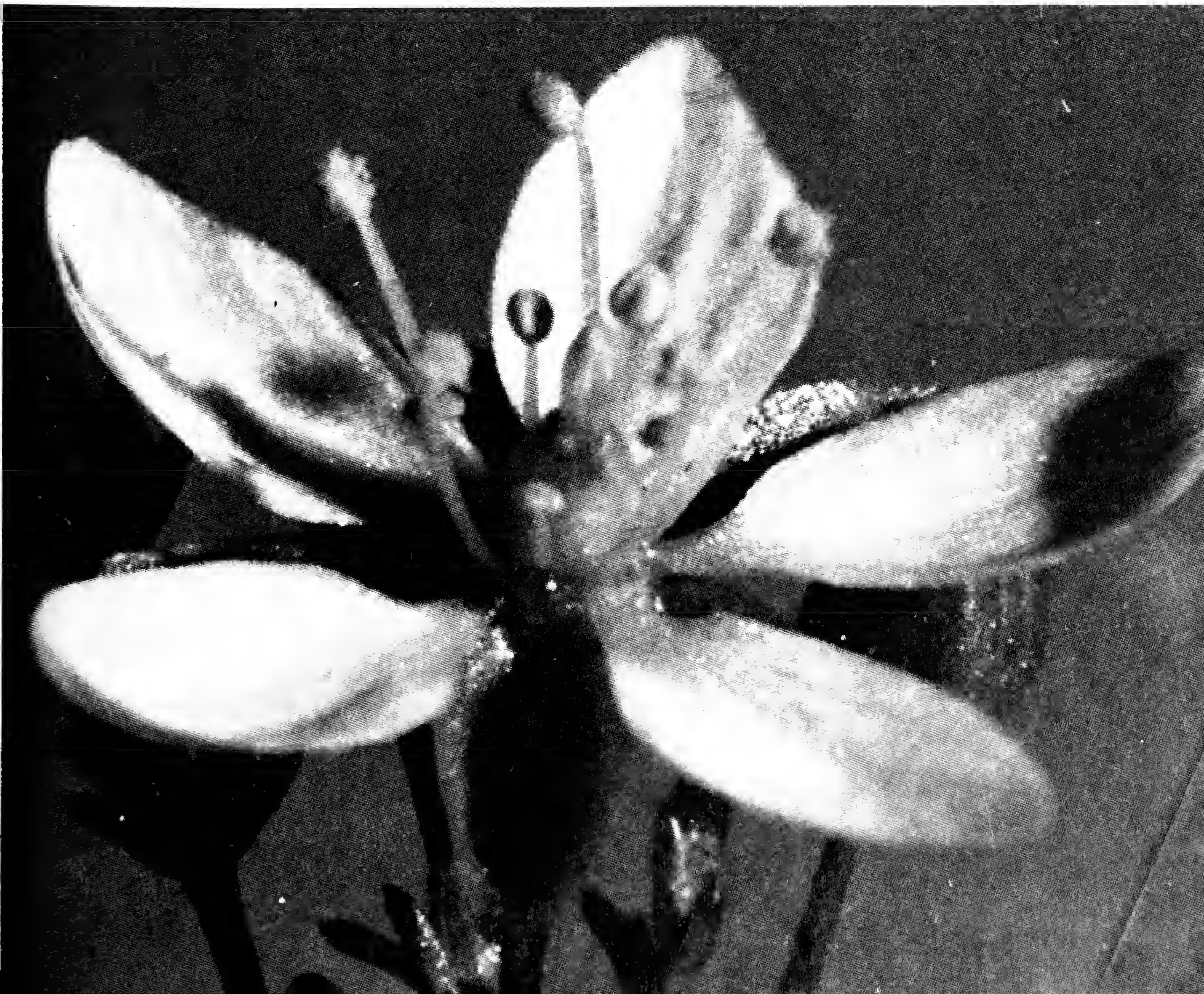

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Back issues beginning with Vol. 14 are $5.00 per volume ($1.25 per number). Complete sets and sets beginning with Vol. 2 are available. On these, as on any order totalling 20 or more copies, a 25% discount is allowed.

Subscriptions (from those not members of the Michigan Botanical Club) and all orders for back issues should be addressed to the business and circulation manager.

Address changes from Botanical Club members should be sent only to appropriate chapter officers. Address changes for *non-member subscribers only* should be sent to the business and circulation manager. Send *no* address changes to the editor.

Articles dealing with any phase of botany relating to the Upper Great Lakes Region may be sent to the editor in chief. In preparing manuscripts, authors are requested to follow our style and the suggestions in "Information for Authors" (Vol. 13, p. 190).

THE MICHIGAN BOTANICAL CLUB

Membership in the Michigan Botanical Club is open to anyone interested in its aims: conservation of all native plants; education of the public to appreciate and preserve plant life; sponsorship of research and publication on the plant life of the State; sponsorship of legislation to promote the preservation of Michigan native flora and to establish suitable sanctuaries and natural areas; and cooperation in programs concerned with the wise use and conservation of all natural resources and scenic features.

Dues are modest, but vary slightly among the chapters and with different classes of membership. Persons desiring to become state members (not affiliated with a local chapter, for which secretaries or other contact persons are listed below) may send $5.00 dues to the Membership Chairman listed below. In all cases, dues include subscription to THE MICHIGAN BOTANIST. (Persons and institutions desiring to subscribe without becoming members should deal with the business and circulation manager as stated at the top of this page.)

A NEW *GRIMMIA* FROM MICHIGAN'S UPPER PENINSULA

Howard Crum
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Ann Arbor 48104

The mosses of Michigan have been collected and studied extensively, but not exhaustively, and some chance of joyful discovery still exists. I tried to give a complete accounting of Michigan species in my *Mosses of the Great Lakes Forest,* published in September of 1973. While it was in proof, I remembered that *Sphagnum quinquefarium* (Braithw.) Warnst. had been collected in Michigan in Mackinac County—by Norton G. Miller and myself, at that! It was inserted as an addendum. Soon after publication, *Dicranum muehlenbeckii* BSG was added to the flora, from Van Buren County (and reported in *The Michigan Botanist* in March of 1974). And now, a new species of *Grimmia* has come to hand, from Copper Harbor in the Keweenaw Peninsula.

It is a special pleasure for me to name this new moss for Frederick J. Hermann, not only because he collected and sent it to me, but also because of his long-time interest in the Michigan flora and his important contributions to Michigan botany, bryological and otherwise. An excerpt from his letter of January 16 has historical interest:

> It's curious that a new species should have turned up so close to "home." I grew up at Laurium, Michigan, but my summers as a boy were spent at Copper Harbor with my great-aunt who owned not only the gorge of the Manganese River, where this *Grimmia* was collected and where Bill Steere was to discover so many western mosses, but most of Copper Harbor. (She died land poor—the property was practically worthless during her lifetime, and I suppose would be worth close to a million now.) While in high school I did a good deal of botanizing at Copper Harbor (sent Bartlett the three color forms of *Corallorhiza maculata* from there, which he described), but only in vascular plants.

Dr. Hermann kindly supplied the Latin description which follows.

Grimmia hermannii n. sp.

Plantae parvae (ca. 5 mm altae) condensato pulvinatae, superne atro-virides, inferne fuscae. *Caules* furcati, erecto-adscendentes, gemmis parvissimis viridibus rotundatis 1-4 cellulis stipitibus filamentosis, plerumque catenatis, in axillis praediti. *Folia* sicca erecta aliquantum contortaque, humectata erecto-patentia usque patentia et plus minusve flexuoso-contorta, 1.2-2.2 mm longa, carinata, anguste lanceolata, gradatim ad acumen gracile contracta, obtuse acuta vel saepius in apicem brevissimum hyalinum plus minusve serrulatum terminata; *margines* latere uno perspicue recurvati in dimidio folii inferiore, nonnumquam latere altera quoque peranguste recurvati; *costa* canaliculata, in foliis muticis subpercurrens, aliis basi apicis hyalini soluta; *cellulae supernae* laeves, 5-7 μ, isodiametrae, parietibus comparate crassis noduliformibusque, seriebus paucis marginalibus in parte foliis superna bistratosis; *cellulae basalares interiores* breves viridesque, subquadratae usque brevi-rectangulares, 1-1.5:1, prope costam haud elongatae, parietibus modice crassis, non vel aliquando parum noduliformes, seriebus cellularum 1-2 marginibus pallidis, subquadratis usque brevi-rectangularibus septis crassis. Ut videtur dioecus (non nisi perichaetia visa).

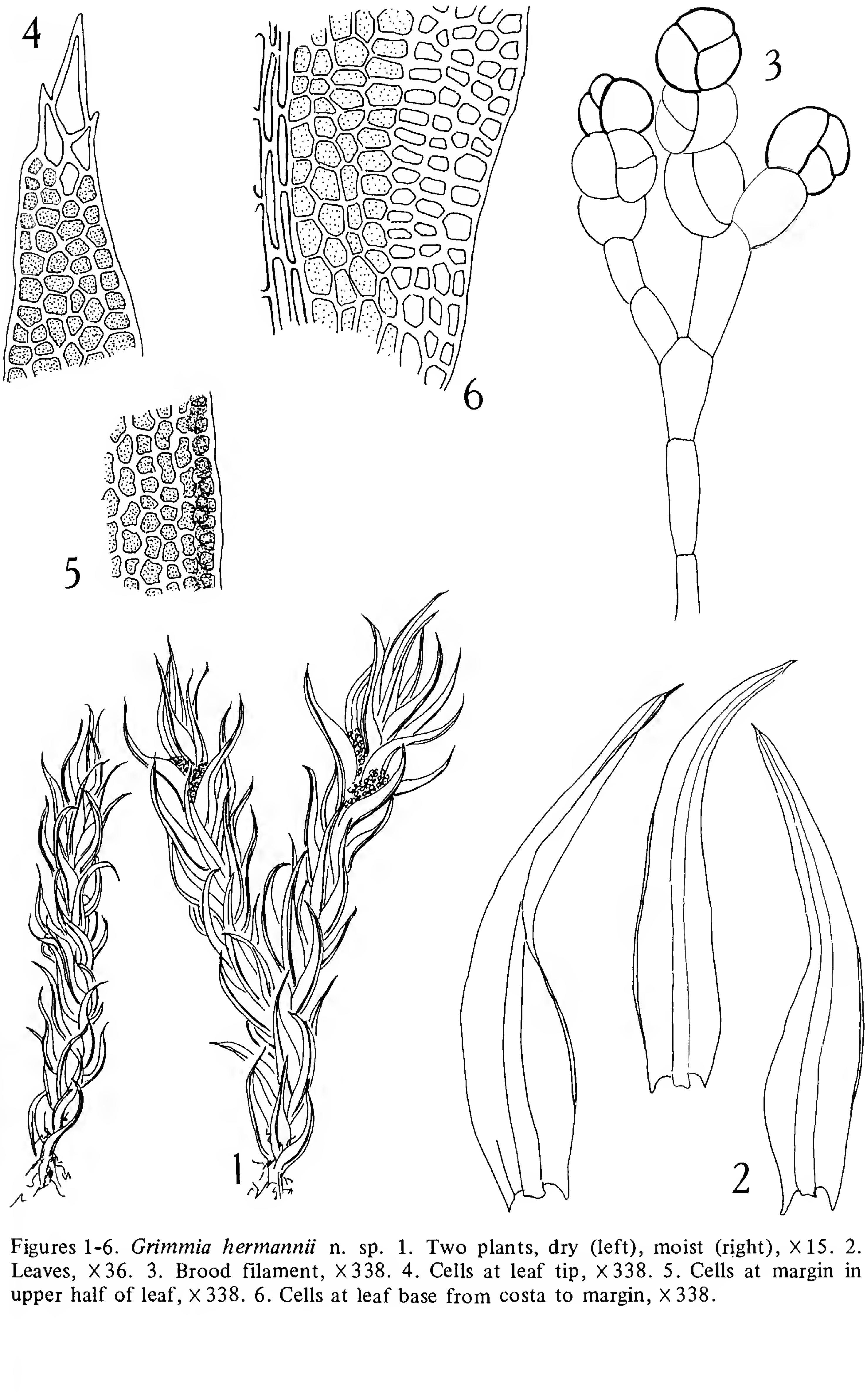
Small plants (about 5 mm high) in dense cushions, dark green above, brown below. Stems forked, erect-ascending. Very small, green, rounded gemmae of 1-4 cells produced on branched filaments in leaf axils, usually in chains. Leaves erect and somewhat contorted when dry, erect-spreading to spreading and somewhat incurved-flexuose when moist, 1.2-2.2 mm long, keeled, narrowly lanceolate, gradually tapered to a slender acumen, bluntly acute or more often ending in a very short, somewhat serrulate, hyaline tip; margins distinctly recurved on 1 side in the lower half of the leaf, sometimes very narrowly recurved on the other also; costa channeled, subpercurrent in muticous leaves, ending at base of the hyaline tip in others; upper cells smooth, 5-7 μ, isodiametric, relatively thick-walled and somewhat nodulose, a few rows at the margins in the upper portion of the leaf bistratose; inner basal cells short and green, subquadrate to short-rectangular, 1-1.5:1, not elongate near the costa, moderately thick-walled, not or sometimes slightly nodulose, 1-2 rows at the margins pale, subquadrate to short-rectangular, with thickened cross-walls. Apparently dioicous (only perichaetia seen).

On boulder in woods below Falls, Manganese River gorge, Copper Harbor, Keeweenaw County, *F. J. Hermann 25446,* July 14, 1973, type in herb. MICH, duplicates in herb. US, NY, DUKE, F, CAN, WTU.

The rounded, green brood bodies produced in chains on filamentous stalks in the leaf axils are generally inconspicuous, though they sometimes occur in dense and obvious clusters too. In addition to the unique type of gemmae, the following characters are distinctive: narrow, keeled leaves with very short hyaline tips; margins recurved on one and sometimes both sides; short, green, scarcely nodulose inner basal cells, not at all elongate near the costa; pale marginal basal cells with thickened cross walls.

In some ways the plants resemble the shade form of *G. pulvinata* (Hedw.) Sm., which was described as *G. indianensis* Sayre, but the very narrow leaves which are contorted when dry and the presence of brood bodies are quite different. They also resemble in some ways, especially the short inner basal cells, *G. trichophylla* var. *tenuis* (Wahl.) Wijk & Marg., previously known as var. *muehlenbeckii* (Schimp.) Husn., but they are much smaller, lack strongly spinulose awns, have much less nodulose inner basal cells, and show no evidence of elongate cells near the costa at base. The axillary brood bodies appear to be different from the brown, multicellular gemmae borne on leaves in *G. trichophylla,* as described and illustrated in Lawton's *Moss Flora of the Pacific Northwest.* (Such gemmae, not seen, seem to be very rare.) The relationship of the Michigan species may be with *G. trichophylla* Grev., but in the absence of sporophytes affinities remain obscure.

It seems appropriate to mention here that *Grimmia affinis* Hornsch. has been collected a number of times in the Upper Peninsula of Michigan, though



Figures 1-6. *Grimmia hermannii* n. sp. 1. Two plants, dry (left), moist (right), ×15. 2. Leaves, ×36. 3. Brood filament, ×338. 4. Cells at leaf tip, ×338. 5. Cells at margin in upper half of leaf, ×338. 6. Cells at leaf base from costa to margin, ×338.

not recorded as such in the literature. This is no doubt the species which Darlington, in *The Mosses of Michigan,* recorded as *G. ovalis* (Hedw.) Limpr. Records of *G. olneyi* Sull., published by Darlington and others, can also be referred here; *G. olneyi* can, in fact, be deleted from our flora. At the University of Michigan, we have the following collections of *G. affinis* from Michigan: On rock near pool along lake shore, Scoville Point, Isle Royale, Keweenaw Co., *A. H. Povah 47,* July 2, 1930 (as *G. olneyi*); on shaded rock near Nebraska Beach, Isle Royale, Keweenaw Co., *A. H. Povah 289a,* Aug. 31, 1930 (as *G. olneyi*); on rock, face of cliff, north exposure, Louise Lookout, Tobin Harbor, Isle Royale, Keweenaw Co., *J. L. Lowe 50,* Aug. 14, 1930 (as *G. olneyi*); on rocks near old lighthouse, Rock Harbor, Isle Royale, *S. C. Stuntz & C. E. Allen 39,* Aug. 7, 1901 (as *G. ovalis*); on gneiss, shore of Lake Superior, Copper Harbor, Keweenaw Co., *F. J. Hermann 16256,* Aug. 26, 1960; on talus, Porcupine Mts., [Ontonagon Co.?], *W. C. Steere 1* (as *G. ovalis*); on soil on boulder, edge of woods, 1 mi. S. of White Deer Lake, 11 mi. NNW of Champion, Cyrus H. McCormick Experimental Forest, Marquette Co., *F. J. Hermann 23706,* June 17, 1971.

News of Botanists and Michigan Botany

Dr. Richard A. Giles, long active in the Michigan Botanical Club and the Michigan Natural Areas Council, retired last spring after 27 years on the faculty of Eastern Michigan University, where he was formerly chairman of the Biology department. Mrs. Giles also retired from the Chemistry department, and they have moved "home" to New England.

Dr. Ronald O. Kapp, another well known Michigan botanist, now provost at Alma College, is president-elect of the Michigan Academy of Science, Arts, and Letters, and will assume the presidency at the 79th annual meeting of the Academy in Ann Arbor in April.

Ruth Mosher Place, honorary member of the Michigan Botanical Club, died in California June 22, 1974. She was one of the first members of the Club in the early 1940's, at which time she was garden editor for the Detroit News. She was also a past president of the Michigan Horticultural Society.

Another honorary member of the Botanical Club, the late Prof. H. H. Bartlett, was honored by the Regents of The University of Michigan last February when they established the Harley Harris Bartlett Professorship in Botany. Named to this professorship in March was Dr. Rogers McVaugh, director of the University of Michigan Herbarium. Six major anthropological and linguistic papers by Prof. Bartlett (and the present editor's biographical sketch and bibliography) have been reprinted in a 416-page volume as Michigan Papers on South and Southeast Asia No. 5 (1973), with the title "The Labors of the Datoe and Other Essays on the Bataks of Asahan (North Sumatra)." It is available for $4.00 from the University of Michigan Center for South and Southeast Asian Studies.

Dr. Frederick J. Hermann retired in June of 1973 after 35 years with the U.S. Department of Agriculture. Since 1961 he had been curator of the Forest Service Herbarium. A native of Michigan's "Copper Country" he is a devoted student of the flora of the state, most recently taking up the mosses (see first article in this issue).

The Nature Conservancy, stating that it "has long felt that Michigan has the conservation ethics coupled with the types of areas that are necessary for a strong and effective land preservation program," has opened a Michigan Field Office at 531 N. Clippert Street, Day Building Suite F, Lansing 48912. G. Rodney Miller is the Michigan Field Representative.

A new organization, the "Friends of the Matthaei Botanical Gardens," was formed last spring to assist in the development of the Gardens at The University of Michigan and its program, including educational and practical aspects of natural history, botanical research, and horticulture. Minimum memberships are $5.00 for students and $10.00 for individuals or couples.

Dr. William T. Gillis, recently a Research Fellow at the Arnold Arboretum of Harvard University, is back in Michigan with an appointment this year on the biology faculty of Hope College, Holland. He is also associated with the Field Museum in Chicago and continues to work on the flora of the Bahamas.

ORTHOTRICHUM RUPESTRE, A MOSS CONFIRMED IN EASTERN NORTH AMERICA

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The genus *Orthotrichum* is represented in Michigan by twelve species and one variety. Six of these taxa, i.e. *O. ohioense* Sull. & Lesq. ex Aust., *O. pusillum* Mitt., *O. sordidum* Sull. & Lesq. ex Aust., *O. speciosum* var. *elegans* (Schwaegr. ex Hook. & Grev.) Warnst., *O. stellatum* Brid., and *O. strangulatum* f. *lescurii* (Aust.) Vitt, are restricted to or have the major portion of their ranges in eastern North America. *Orthotrichum anomalum* Hedw., *O. obtusifolium* Brid., *O. pumilum* Sw., and *O. speciosum* Nees ex Sturm are widely distributed in the western cordillera and extend into eastern North America only north of the line of maximum glaciation (a few have isolated stations farther south). *Orthotrichum pallens* Bruch ex Brid. occurs sporadically in the western cordillera with disjunct populations in northern Michigan, northern Minnesota, the Bruce Peninsula, and the Gaspé Peninsula. *Orthotrichum alpestre* occurs from the Black Hills, South Dakota, westward, with a disjunct occurrence on the Keweenaw Peninsula of Upper Michigan.

While examining material of the Orthotrichaceae from the herbarium of the University of Minnesota, I found two specimens of *Orthotrichum rupestre* Schleich. ex Schwaegr. from eastern North America. One of these was collected on Isle Royale, Michigan, while the second was from Grand Portage, Minnesota. *Orthotrichum rupestre* is distinguished by superficial stomates; nodose, elongate basal leaf cells; smooth or lightly 8-ribbed, oblong capsules which are emergent; and a peristome of 16 erect exostome teeth. This species along with *O. sordidum* are the only representatives of the section *Rupestria* Schimp. found south of the Gaspé Peninsula in eastern North America.

Orthotrichum rupestre is known in western North America from southern Alaska and the Yukon Territory, east to northeastern Alberta, and south in the western mountains to southern California and northeastern New Mexico. Its continuous range extends east to the Black Hills, South Dakota. It is found on non-calcareous boulders and cliff faces in xerophytic to mesophytic coniferous forests. The Cook Co., Minnesota, and Isle Royale, Michigan, populations are decidedly disjunct and confirm the presence of this species in eastern North America. Grout (Moss Flora of North America North of Mexico, II(2):110. 1935.) did not record *O. rupestre* from eastern North America. As far as I know, the present report is the first published record of the species in this region. However, in a recent revision of the genus (Vitt, A Revision of the Genus *Orthotrichum* in North America, North of Mexico, Bryophyt. Biblioth. 1:90. 1973.) three collections were reported as *O. rupestre,* but were considered dubious until further collections could document the species' presence in eastern North America. These records [Exploits, Newfoundland, *Waghorne* (NY); White Mountains, New Hampshire, *Oakes* (MICH); and Clyde Inlet, Baffin Island, *Steere* (NY)] now seem supported as probable disjunct stations by the additional collections presented here from disjunct localities in Minnesota and Michigan.

Specimens Examined: MICHIGAN–Isle Royale: On island above Raspberry Island, *Cooper 106,* July 23, 1910 (MIN). MINNESOTA–Cook Co.: Hat Point, on peninsula projecting southward from Mt. Josephine, into Lake Superior, near Grand Portage at latitude 48°N, *Holzinger,* Aug. 15, 1902 (MIN).

I would like to thank Dr. Clifford Wetmore for loan of herbarium specimens and the National Research Council of Canada for grant A-6390 in support of this research.

ABERRANT PISTILLATE CATKINS OF *BETULA ALLEGHANIENSIS*[1]

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Researchers making extensive population studies commonly encounter unusual variants. The greater the sizes of the populations examined, the greater the likelihood of finding peculiar forms. Statistically, of course, this is to be expected. The following discovery is a good example of what is generally referred to as a "monstrous form," in this case involving the birch catkin and its over-all structure.

In 1971, while making collections for a genecological study of yellow birch (*Betula alleghaniensis* Britton) in the westen Great Lakes region, we discovered a single tree that bore aberrant pistillate catkins. Most of the catkins had the normal, single, unbranched rachises, but many had rachises that branched (Fig. 1). The plant grew on a slope along the Jordan River in

[1]Support for genecological studies of the birches provided under the McIntire-Stennis Law (P.L. 87-788) is gratefully acknowledged.

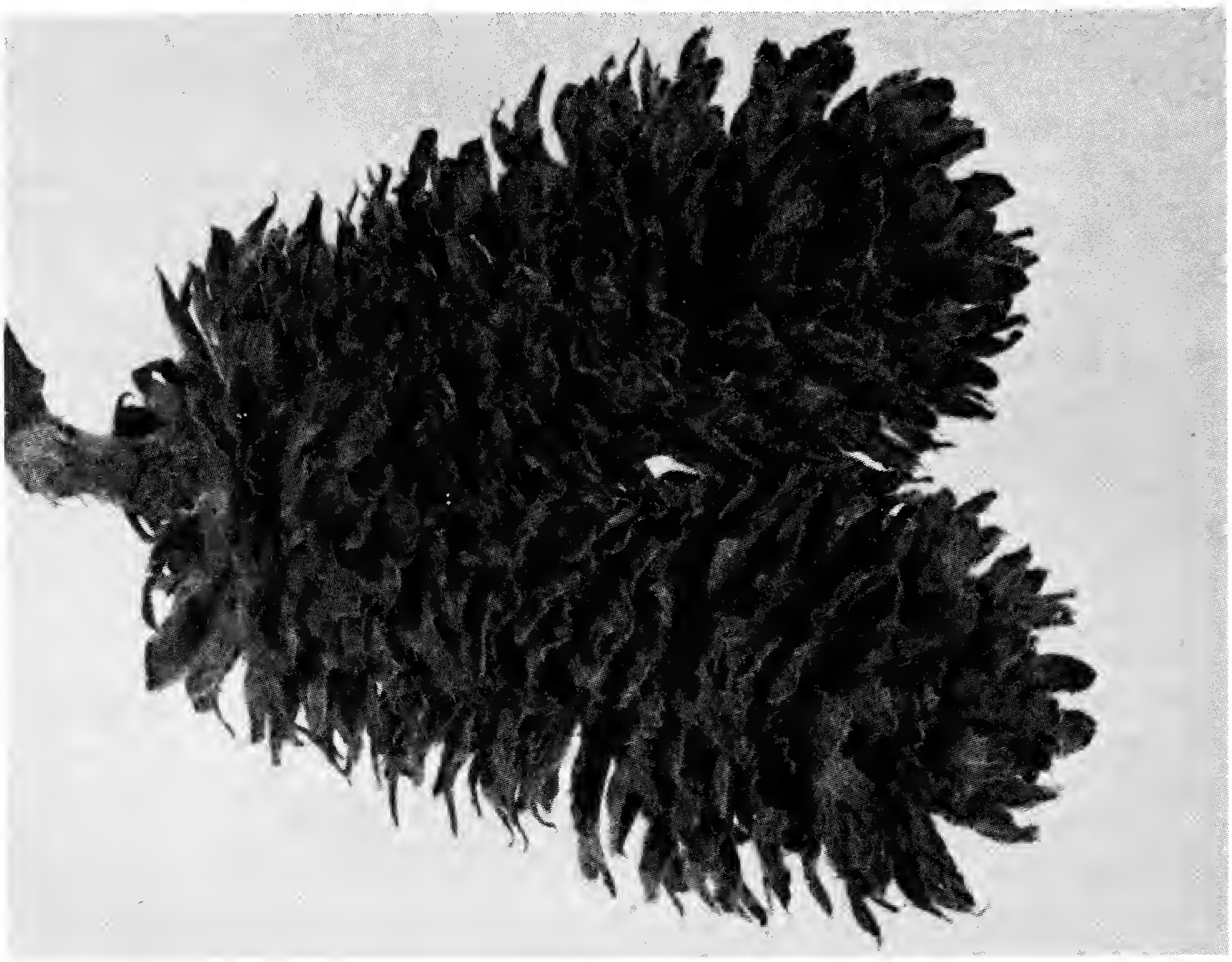

Fig. 1. An aberrant pistillate catkin of yellow birch (*Betula alleghaniensis*).

Antrim County, Michigan (SESW Sec. 1, T30N, R6W) (*Dancik 69BD071*, MICH). We had observed similar catkins on one tree in Upper Michigan in 1967.

As seen in Figure 1, the aberrant catkins are more or less equally forked, so that there are two distinct axes, both of which bear normal bracts and fruits. The general form suggests a dichotomous organization of the axes, as if the meristem which normally grows straight and forms a single axis branches equally and thus makes effectively two catkins fused at the base.

Whether the "double" catkins of this single plant of yellow birch should be considered as a form of, or related to, fasciation is a question. Many plants are known to form flattened meristems and fan-like stems, such as those of the garden cockscomb flower, *Celosia*. Such fasciated stems have long attracted attention (Worsdell, 1916). They differ, however, from the catkins described here in having flat expanses of axial tissue arranged in a more or less fan-like manner. Probably the best description of the phenomenon described here is "bifurcating inflorescence" (cf. Worsdell, op. cit., p. xxxii). That it may indeed be related causally to fasciation is possible, but the results are different.

Perhaps the most remarkable feature of any bifurcating axes in seed plants is that the mature branching pattern is basically monopodial or axial in these plants. Therefore, it is unexpected to find equally or subequally divided cones, flowers, or catkins. We have not determined whether such branching is truly dichotomous from an ontogenetic standpoint, but the mature form distinctly shows equal or nearly equal furcations. Zimmerman (1959) has based a whole theory of origin of higher plants on the concept that dichotomous axes are primitive; if this is actually true, then the condition seen in this birch might be a "throwback," or atavism. On the contrary, what we have observed here probably has no phylogenetic significance. The problem of what value to place upon such phenomena as these has been analyzed by Heslop-Harrison (1952) who takes a cautious stand. Some authors, however, tend to regard examples such as that described here as possessing phylogenetic significance.

Like or related phenomena have been long known in Betulaceae. Linnaeus referred to an undue number of branches as "plica"; other authors have called it "polyclady" (Masters, 1869). Masters (op. cit., Fig. 181) illustrates an increased number of male catkins in the hazel of Europe (*Corylus avellana* L.).

Examples of double- and triple-forked male cones have been reported for western white pine (*Pinus monticola* Dougl.), and fasciated and apparently forked male cones are known from one individual in ponderosa pine (*Pinus ponderosa* Laws.) (Bingham et al., 1969).

We believe that the condition described here is extremely rare, judging from our field studies. The two occurrences that we have noted represent less than one percent of our samples, actually only two out of over 1,500 yellow birch trees studied! We do not believe that the condition as we found it in the two examples was due to local environmental factors causing injury to the growing apex. It seems more likely that the condition results from internal, genetic causes.

We wish to call attention to this phenomenon and hope that readers will be on the lookout for other examples which we can study ontogenetically.

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Reviews

INSCAPE AND LANDSCAPE. Massey Lectures, Twelfth Series. By Pierre Dansereau. Canadian Broadcasting Corporation, 1973. 118 pp. $2.00 (from CBC Learning Systems, Box 500, Station A, Toronto, Ontario M5W 1E6).

Borrowing from a poet the concept of "inscape," Pierre Dansereau here considers in a truly grand sweep man's selective perception of the world about him as well as his impact on nature. ". . . the richness of our inscapes is a preliminary to a good management of our landscapes." The chapters were originally a series begun by the CBC "to enable distinguished authorities in fields of general interest and importance to present the results of original study or research." Available now in convenient paperback form, they constitute a remarkably articulate and lucid historical overview of ecology with special emphasis on man in nature–not over and above it. (Note: The University of Michigan radio stations, WUOM/WVGR, plan to broadcast these lectures on the "Morning Show" at 10:05 in the near future.)

The elementary background in Chapter II presents the distinctions between flora and vegetation, the principal vegetation patterns of the world, the exchanges between environment and organism. Continuing into Chapter III, we learn more of the triangular interactions of climate, soil, and vegetation and find a useful consideration of sharing processes, or "cooperation," as well as competition among plants. Subsequent chapters lead us into ecosystem analysis, cycling of resources and energy at various levels, and what this all means to man's designs and management (or mismanagement). (Imagine a greatly enlarged version of the article in Cranbrook News Letter. December 1967.) We read of the "vast conspiracy of advertising" and the problems now that ecology is a by-word: "The change of gear among old-time ecologists, the assumptions of the converts, and the claims of the new generation do not necessarily permit very smooth driving of this new bandwagon."

Readers who already know Dr. Dansereau, perhaps from his 1950-1955 years on the University of Michigan botany faculty or his 1967-1968 residency as Distinguished Scholar at Cranbrook Institute of Science, will not be surprised at the vast scope here presented, the broad range of examples from the Great Lakes to New Zealand, the startling diversity in the list of references: Aesop to Emile Zola, via Agnes Arber, Marston Bates, Kenneth Boulding, Stanley Cain, Alphonse De Candolle, Barry Commoner, H. C. Cowles, Charles Dickens, T. S. Eliot, Walt Kelly, Rudyard Kipling, Paul Sears, L. Dudley Stamp, Barbara Ward, John Weaver, and dozens of others!

Reading the capsule description (p. 72) of succession on an "oil-field" in Georgia reminds me of the 1954 program of the Michigan Academy of Science, Arts, and Letters (which Dansereau probably attended), where Marion Hall was scheduled to compare juniper populations on an Ozark glade and an oil-field. Major oil companies could surely use the secret of the typesetters' alchemy which converts old fields into oil fields!

–E. G. V.

LAKE ERIE BIBLIOGRAPHY IN ENVIRONMENTAL SCIENCES. By Charles E. Herdendorf, Suzanne M. Hartley, & L. James Charlesworth. Franz Theodore Stone Laboratory Contr. 13. Bull. Ohio Biol. Surv. n. s. 4(5). 1974. 116 pp. $3.50 (from OSU Publication Sales, Room 20 Lord Hall, 124 W. 17th Ave., Columbus, Ohio 43210).

Published in cooperation with the Center for Lake Erie Area Research (at least the acronym is CLEAR), this bibliography includes approximately 3,000 titles from 1800 to mid-1972. These are listed alphabetically by author under 11 subdivisions, including at least two with specific botanical content: Biological Limnology and Coastal Botany. Publications on algae and fungi seem to be listed in the former subdivision, those on mosses and vascular plants in the latter. Only a few titles are annotated with brief explanations. Many of the publications pertain to Michigan (including J. M. Sutton's "Flora of the Detroit Zoological Tract" which has, however, nothing whatsoever to do with Lake Erie).

–E. G. V.

NEW LOCALITIES FOR *NAJAS MINOR* AND *N. MARINA* IN SOUTHEASTERN MICHIGAN

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Najas minor Allioni is a European bushy pondweed of recent introduction to the United States. It was discovered in 1934 by R. T. Clausen in New York's Hudson River at the mouth of the Mohawk River; this was long considered the earliest record, but Wentz and Stuckey (1971) have found specimens collected by Lawrence E. Hicks on 28 August, 1932, in Ashtabula County, Ohio (OS), previously misidentified as *Najas marina* L.

Studies of the distribution of *N. minor* by Fore and Mohlenbrock (1966) and by Meriläinen (1968) show that it is becoming very widespread in North America, occurring in the eastern U.S. from Lake Ontario west to Illinois and south to northern Florida. Voss (1972) cited only one locality for *N. minor* in Michigan, the marshes of the Pte. Mouillée State Game Area (*M. McDonald 5318, 5783,* in 1949 and 1950 MICH, MSC).

On 7 August, 1972, *N. minor* was collected by Belcher in southwestern Oakland County from Kent Lake adjacent to the West Boat Launching site (*Belcher 72-23A,B,*EMC), but was erroneously identified as *N. marina* until Dr. Voss visited the site soon after. In October, 1972, Belcher again observed abundant material of *N. minor* at several localities in Kent Lake north of I-96, but not south of I-96 in the Livingston County portion of the lake. Searches in southeastern Michigan in the summers of 1973 and 1974 under the auspices of a grant from the College Science Improvement Program at Eastern Michigan University have turned up several additional stations as listed below.

Voucher specimens of *N. minor* have been deposited in the herbarium at Eastern Michigan University (EMC) from all of the following localities:

Livingston County—
Whitmore Lake, public access site, Sept. 15, 1973, *Near* (EMC 19126).

Oakland County—
Kent Lake, Kensington Metropark: southwest of East Boat Launch, June 28, 1973, *Near* (EMC 19121), west bank of cove, east of Maple Beach, July 9, 1973 *Near* (EMC 19122), west Boat Launch, June 25, 1973, *Near* (EMC 19124), north of West Boat Launch, near small island, June 26, 1973, *Near* (EMC 19127); Stony Creek Lake, Stony Creek Metropark: narrows between small island and Winter Cove shore, July 17, 1973, *Near* (EMC 19123).

Washtenaw County—
Youngs' Gravel Pit, northeast bay, Huron River Drive near Textile Road, Ypsilanti Twp., Sept. 13, 1973, *Near* (EMC 19118).

Specimens of *N. minor* have been positively identified but not preserved from the following additional localities:

Livingston County–
American Aggregrate Corporation "Trout Pond," sec. 12, Green Oak Twp., July 16, 1974.
Macomb County–
Stony Creek Lake, cove south of Eastwood Beach, sec. 36 of Washington Twp., and large bay southeast of the North Dam, sec. 26, Washington Twp., July 17, 1973.
Washtenaw County–
Pond at Woodland Hills Apartments, sec. 12 of Pittsfield Twp., July 5, 1974; Pleasant Lake, sec. 22, Freedom Twp.

N. minor was extremely abundant in Kent Lake during the summer of 1973, being recovered at a majority of all near-shore sites sampled from the upper end, north of Dawson Road, all the way to the dam west of the public beach in Island Lake State Recreation Area, on both sides of the lake and around several of the scattered islands. In several places it was the local dominant, forming dense monopolistic stands in shallow water. It was almost as common in Stony Creek Lake, particularly in the lower basin. These lakes are both drawn down approximately one meter each autumn to minimize ice damage to shore installations during the winter. (Stony Creek Lake was lowered almost two meters in the winter of 1972-73, however, for repairs to the main launch site.) This drawn-down appears especially destructive of *Myriophyllum spicatum* L. and *Ceratophyllum demersum* L., which in many places form dense mats downward from the one-meter contour. It is in this disturbed zone, especially on sandy and silty bottoms, that *N. minor* seems to flourish best. It does not appear to colonize marl or soft organic muds, and is thus unlikely to be found with *Elodea* spp. or with *Chara* spp. except when the latter is invading sandy shallows.

Our original hypothesis, that it would be confined to these draw-down zones, was invalidated by our finding it late in the 1973 season both in Whitmore Lake and Youngs' Gravel Pit, whose levels are much more stable, and also at numerous points in the Huron River from immediately below Kent Lake Dam westward to Kensington Road. We had seen numerous fragments of *N. minor* floating in the lake just above the dam, some with developing adventitious roots, and expected to find these fragments in the flotsam downstream; but in addition we found the plant well established at intervals along the bottom as well as along the banks. We have also seen it in 1974 in several lakes that have only modest fluctuations. It may be noteworthy that in these naturally stable lakes it seems rarely if ever to attain the abundance seen in the two impoundments.

Wentz and Stuckey (1971) and Meriläinen (1968) concluded that *N. minor* is a species which thrives in eutrophic waters, tolerates pollution to some degree, and therefore may be displacing native naiads which are less tolerant. This conclusion may be valid, but the American Aggregate Trout Pond in Green Oak Twp. is an isolated ex-gravel pit of exceptional clarity, as near to oligotrophic as southern Michigan waters can come, and it supported colonies of *N. minor* at several points. It may be significant that these plants

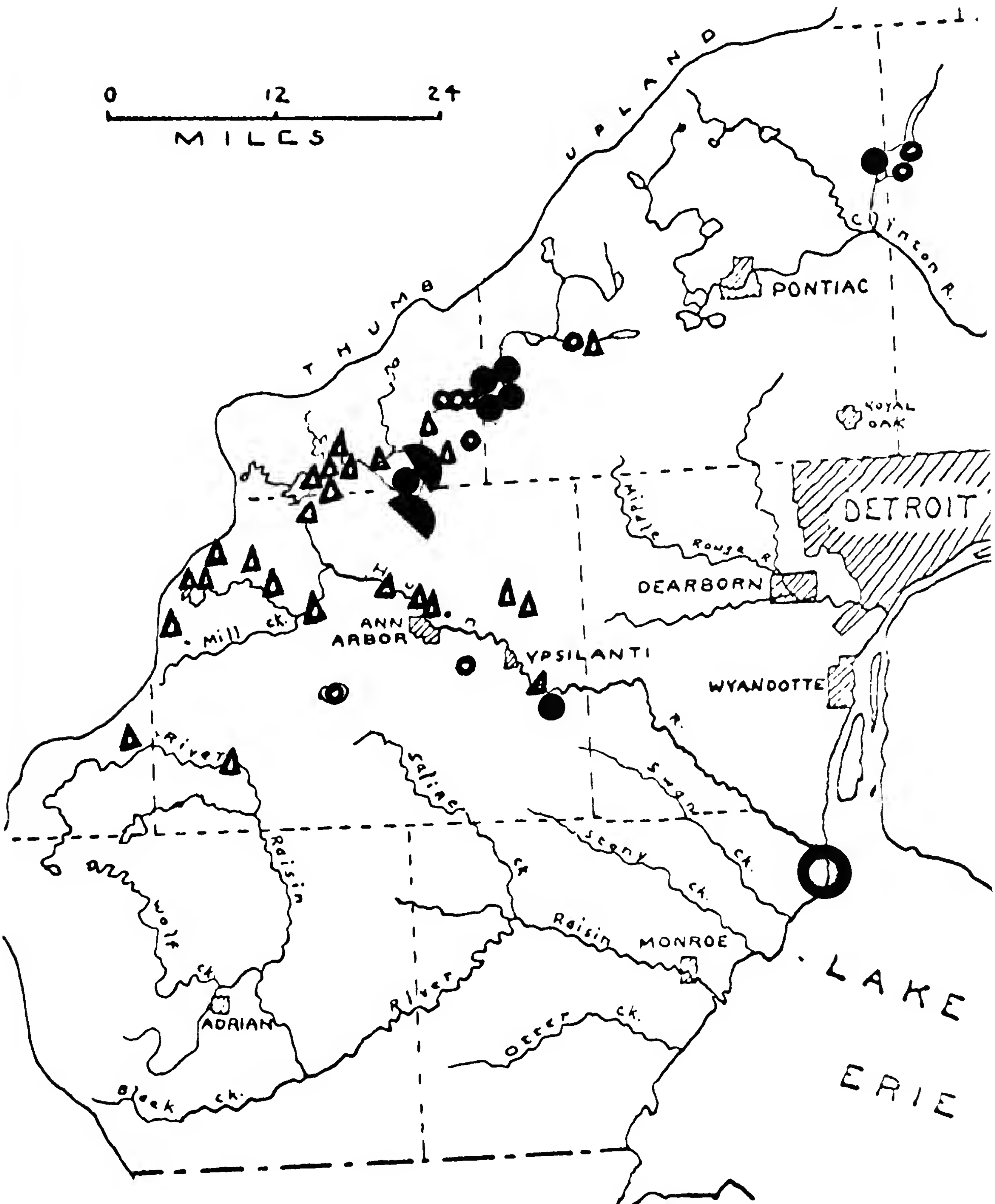

Fig. 1. Distribution of *Najas minor* and *N. marina* in southeastern Michigan. (Base map revised from Hudgins, "Michigan: Geographic Background in the Development of the Commonwealth," p. 18.)

- Vouchered record of *Najas marina,* 1973-1974.
- Vouchered record of *N. minor,* 1972-1973.
- *N. minor* identified (no specimen preserved), 1973-1974.
- *N. minor* collected in 1949 & 1950, not seen in 1973.
- Locality searched 1973-1974, neither species seen.

had much shorter internodes than those collected elsewhere, a condition which appears to be persisting in rooted specimens held in the aquarium. We also found *N. flexilis* to be locally abundant in most of the eutrophic lakes examined. There also was a noted decrease in the 1974 abundance of *N. minor* in Youngs' Gravel Pit from the 1973 study; this may be due to the high concentration of silt caused by nearby road construction.

Our failure to find *N. minor* at Pointe Mouillée, site of the first Michigan collection, we attribute to the combination of recent massive erosion of that marsh coupled with the current high level of Lake Erie. It is to be expected that this species will eventually spread all the way downstream in the Huron River from the abundant seed source in Kent Lake. That it is somewhere in the Upper Huron is attested by a fragment found floating just below Proud Lake Dam in 1974, even though a fairly thorough search of Proud Lake in 1973 was negative. A similar spread down into the Clinton River from Stony Creek Lake may also be expected.

A scrappy but unmistakable fragment of *Najas marina* L. was collected by Near (*N 199*) in Whitmore Lake on Sept. 19, 1973, during a search for additional stations of *N. minor*. We made additional searches in Whitmore Lake in the fall of 1973 and in early summer and mid-summer of 1974 without success. In August, however, in a careful examination of most of the perimeter of the lake, additional scattered fragments of *N. marina* were found stranded on the shore, entangled in emergent sedges, or drifting alongshore. It was found both in the northeastern side of the lake in Livingston County (EMC 19116) and more numerously in the southern bays in Washtenaw County (EMC 19117). No specimen was found rooted in place, although several fragments had developed adventitious roots. One long floating piece had silty organic sand still clinging to basal roots; this was grown for some weeks at Eastern but eventually disintegrated.

All the 1974 material appeared etiolated, suggesting a habitat near the bottom of the photic zone. After efforts to recover material from deeper water by dredging were unsuccessful, several dives were made with SCUBA gear to probe the southern and eastern slopes of the southern basin. No *N. marina* was seen in the areas sampled. The slopes were mostly covered with dense stands of *Myriophyllum spicatum* or *Chara,* with a basal border of tall *N. flexilis.* The flat bottom at a depth of about 35 feet was a barren soft organic ooze.

N. marina is undoubtedly growing somewhere in Whitmore Lake, but it has proved most elusive. The fragments so far recovered, up to a meter long, appear to have been broken off by some of the fishermen who anchor in virtually all parts of the lake. We believe that if there were beds near enough to the surface to be cut off by passing propellers we would have found them.

Additional localities which were rather thoroughly sampled out to a depth of a meter or more, but in which neither *N. minor* nor *N. marina* was seen, include:

Livingston County—

Island Lake (public frontage); other more recent gravel pits of American Aggregate Co. in Green Oak Twp.; Base Line, Whitewood, Gallagher, Strawberry, and Zukey Lakes and connecting reaches of the Huron River; Huron River adjacent to the public campsite southwest of Island Lake in Island Lake State Recreation Area and at M-36.

Washtenaw County–

Four Mile Lake (south tip) and adjacent marl pits; Cavanaugh Lake (entire perimeter); Mill Lake (northwest quadrant); Sugar Loaf Lake (most of perimeter); South Lake (northeast corner); portions of Ford Lake; Murray Lake (entire perimeter); Mill Creek between I-94 and Parker Road; Raisin River at and below Sharon Hollow Mill Dam; Huron River below Portage Lake Dam, at Delhi Rapids and at Argo Pond; Fleming Creek impoundment east of Cherry Hill Road; Thurston Nature Center Pond, Ann Arbor; and numerous small unnamed ponds.

Jackson County–

Sweezey Lake (southwest quadrant).

LITERATURE CITED

Fore, Paul L., & Robert H. Mohlenbrock. 1966. Two new naiads from Illinois and distributional records of the Naiadaceae. Rhodora 68: 216-220.

Meriläinen, Jouko. 1968. Najas minor All. in North America. Rhodora 70: 161-175.

Voss, Edward G. 1972. Michigan Flora Part I: Gymnosperms and Monocots. Cranbrook Inst. Sci. Bull. 55. 488 pp.

Wentz, W. Alan, & Ronald L. Stuckey. 1971. The changing distribution of the genus Najas (Najadaceae) in Ohio. Ohio Jour. Sci. 71: 292-302.

Publications of Interest

SHRUBS AND VINES FOR NORTHEASTERN WILDLIFE. By John D. Gill and William M. Healy [eds.]. U.S. Dep. Agr., NE For. Exp. Sta., Genl. Tech. Rep. NE-9. 1974. 180 pp. A non-technical handbook which compiles much information on habitat, life history, uses, and management–but not identification. 100 native and naturalized shrubs and woody vines are treated, often by genus or group of species. Available from Northeastern Forest Experiment Station, 6816 Market St., Upper Darby, Pennsylvania 19082.

BETTER WATER FOR BETTER LIFE. Institute of Water Research, Michigan State University. n. d. [1974?]. 40 pp. A general presentation, with special reference to projects associated with the Institute of Water Research. Points out that within the legal boundaries of Michigan is a third of all the fresh water in the United States. Illustrations are copious but often distractingly colored.

GREAT LAKES BASIN, Part I. Part II. Business and Technology Sources (Bull. Business Info. Sci. Tech. Deps., Cleveland Public Library). Vol. 41, nos. 2 & 3. 1970. 8 pp. ea. $.25 ea. Lists "a sampling of recent publications" concerning the Great Lakes Basin, including sections on Botany, Limnology, Natural Resources, and Wildlife (all in Part II). Listing is alphabetical by title in each section; authors are often not even cited, a deplorable practice!

MICHIGAN PLANTS IN PRINT

New Literature Relating to Michigan Botany

This section lists new literature relating to Michigan botany under four categories: A. Maps, Soils, Geology, Climate (new maps and selected bulletins or articles on matters useful to field naturalists and students of plant distribution); B. Books, Bulletins, etc., and C. Journal Articles (listing, respectively, all separate publications and articles in other periodicals which cite Michigan specimens or include research based on plants of wild origin in Michigan—not generally including work on cultivated plants nor strictly economic aspects of forestry, conservation, or agriculture); D. History, Biography, Exploration (institutions as well as travels and lives of persons with Michigan botanical connections). When the subject matter or relation to Michigan is not clear from the title, annotations are added in brackets. Readers are urged to call to the editor's attention any titles (1960 or later) which appear to have been overlooked—especially in less well known sources.

—E. G. V.

A. MAPS, SOILS, GEOLOGY, CLIMATE, GENERAL

Brewer, Richard (ed.). 1973. A Bibliography of the Ecology of Kalamazoo County, Michigan. Inst. Public Affairs, West. Mich. Univ., Kalamazoo. 32 pp. $2.00. [Includes unannotated lists of references on geology, soils, climate, vegetation, lakes and ponds, vegetation, birds and mammals, land use, and other topics pertaining to Kalamazoo County or "nearby areas." One can always think of additions or question criteria for includion; but the fact remains that Kalamazoo County is apparently the first in the state to have so thorough a bibliography prepared.]

Herdendorf, Charles E., Suzanne M. Hartley, & James Charlesworth. 1974. Lake Erie Bibliography in Environmental Sciences. Franz Theodore Stone Lab. Contr. 13. Bull. Ohio Biol. Surv. n. s. 4(5). 116 pp. +3.50. [Includes subdivisions on geology, soils, climate, and other background subjects as well as botany; see review on p. 180 of this issue. See also the "Great Lakes Basin" bibliographies noted on p. 185.]

Huber, N. King. 1973. The Portage Lake Volcanics (Middle Keweenawan) on Isle Royale, Michigan. U.S. Geol. Surv. Prof. Pap. 754-C. 32 pp. $1.05. [Deals with the principal formation outcropping on Isle Royale, well correlated with Keweenaw Peninsula of the mainland. Photos, diagrams, maps.]

Merva, George E. 1974. pH Variation in Michigan Rainfall. Mich. Agr. Exp. Sta. Res. Rep. 234. 8 pp. [Data all from Ingham Co.]

(Michigan Department of Agriculture, Michigan Weather Service). 1974. Supplement to The Climate of Michigan by Stations. For the Period 1940-1969. 26 pp. [Consists entirely of maps, which present some of the data which are contained in tabular form in the original publication, noted in our March 1973 issue. Also available from the Michigan Weather Service (1407 S. Harrison Rd., East Lansing 48823) are "Corrections and Additions" for The Climate of Michigan by Stations. These consist chiefly of changes in statistics, not historical information as noted here before.]

Schneider, Ivan F., & Eugene P. Whiteside. 1974. Status of Michigan Soil Surveys. Mich. Agr. Exp. Sta. Res. Rep. 240. [3] pp. [Presents, with map, status of soil survey work completed or in progress for all counties. Only Lake County has had no soil or land type survey at any time.]

Warncke, D. D., & E. C. Doll. 1973. Organic Soil Test Levels and Changes in Michigan, 1962-72. Mich. Agr. Exp. Sta. Res. Rep. 233. 7 pp. [Presents data on pH and nutrient levels for organic soils in all regions of the state.]

Wolff, Roger G., & N. King Huber. 1973. The Copper Harbor Conglomerate (Middle Keweenawan) on Isle Royale, Michigan, and Its Regional Implications. U.S. Geol. Surv. Prof. Pap. 754-B. 15 pp. + map in pocket. $.95. [Deals with a formation that outcrops from Cumberland Point to the area of Malone Bay; includes some data, with maps, from mainland as well. Unfortunately, the Government Printing Office produced so few copies that this publication went out of print less than 8 months after it was issued.]

B. BOOKS, BULLETINS, SEPARATE PUBLICATIONS

Behr, Eldon A., & Wayne Myers. 1973. Decay Resistance of Northern White Cedar from a Wet Site in Lower Michigan. Mich. Agr. Exp. Sta. Res. Rep. 229. 10 pp. [General discussion of decay and resistance, with data on trees cut in Presque Isle Co.]

Gill, John D., & William M. Healy (eds.). 1974. Shrubs and Vines for Northeastern Wildlife. U.S. Dep. Agr., NE For. Exp. Sta. Genl. Tech. Rep. NE-9. 180 pp. [Michigan occasionally mentioned as source of data on wildlife use, associated species, etc.—and somewhat more Michigan data are included for the sumacs. See also note on p. 185 of this issue.]

Hale, Mason E., Jr. 1973. Fine Structure of the Cortex in the Lichen Family Parmeliaceae Viewed with the Scanning-electron Microscope. Smithsonian Contr. Bot. 10. 92 pp. [Figure of *Cetraria halei* is from Michigan material.]

Schuster, Rudolf M. 1966. The Hepaticae and Anthocerotae of North America East of the Hundredth Meridian. Vol. I. Columbia Univ. Press, New York. 802 pp. $25.00. [Most of this volume is devoted to general introductory material; however, 5 species are cited from Michigan localities. See next two entries below.]

Schuster, Rudolf M. 1969. The Hepaticae and Anthocerotae of North America East of the Hundredth Meridian. Vol. II. Columbia Univ. Press, New York. 1062 pp. $20.00.

Schuster, Rudolf M. 1974. The Hepaticae and Anthocerotae of North America East of the Hundredth Meridian. Vol. III. Columbia Univ. Press, New York. 880 pp. $25.00. [In vols. II and III, numerous species are cited from Michigan localities, especially when at periphery of range, and some of the excellent drawings are based on Michigan collections. Michigan is sometimes merely mentioned in the range of commoner species, and local habitat data are sometimes included in the ecological discussion. This thorough monograph of the liverworts is still in course of publication, with keys and illustrations (no maps). Appearance of Vol. III reminds us that no notice has here been taken of the first two folumes.]

Shetron, Stephen G. 1974. Variation in Oak on Sandy Soils in Baraga County, Michigan. Mich. Tech. Univ., Ford For. Center Res. Note 11. 9 pp. [Compares morphology of red oak on Omega Sand and Keweenaw Loamy Sand, discusses possible identification with other species, and concludes that the "scrub oak site represents the extreme end in range of *phenotypic* plasticity for the red oak species." The same sentence appears in the Summary but the key word is there *genotypic.*]

Vitt, Dale H. 1973. A Revision of the Genus Orthotrichum in North America, North of Mexico. Bryophytorum Bibliotheca 1. 208 pp. + 60 pl. $24.00. [The plates include dot distribution maps, which indicate 10 species in Michigan, and selected specimens are cited in the text. See also article on pp. 176-177 of this issue.]

C. JOURNAL ARTICLES

Bigelow, Howard E. 1973. The genus Clitocybula. Mycologia 65: 1101-1116. [Four of the six species are cited from Michigan, without further locality.]

Botkin, D. B., P. A. Jordan, A. S. Dominski, H. S. Lowendorf, & G. E. Hutchinson. 1973. Sodium dynamics in a northern ecosystem. Proc. Natl. Acad. Sci. 70: 2745-2748. [Work on Isle Royale, indicating fairly high sodium content of freshwater vegetation, a major item in the diet of moose. Inclusion of *Juncus gerardii* in list of species analysed seems doubtful.]

Bruce, James G. 1972. Observations on the occurrence of the prothallia of Lycopodium inundatum. Am. Fern Jour. 62: 82-87. [Work done in Midland and Van Buren cos.]

Cooperrider, Tom S., & Bruce L. Brockett. 1974. The nature and status of Lysimachia ×producta (Primulaceae). Brittonia 26: 119-128. [Cites two Michigan collections of *L. terrestris,* supplementing earlier data presented by Ray, and for *L.* ×*producta* localities in Kalamazoo and Branch counties, the latter the type locality for the hybrid (both of these included in map).]

Harman, Jay R., & Michael D. Nutter. 1973. Soil and forest patterns in northern Lower

Michigan. East Lakes Geographer 8: 1-12. [Compares presettlement and current forest composition on different soil types in Antrim and Montmorency counties and speculates that climatic differences ("lake effect") may be responsible for the greater variety of soil textures on which mesic species are competitive in Antrim County compared to greater drought stresses farther inland. Considers effects of logging and fire, and notes that balance of species has shifted since pre-settlement times, as illustrated by conspicuous decreases in pines, hemlock, and beech; in many ways the work is similar to that of Kilburn (two 1960 papers and 1957 thesis) in nearby Cheboygan County, although his work is not cited.]

Hill, Royce H. 1971. Comparative habitat requirements for spore germination and prothallial growth of three ferns in southeastern Michigan. Am. Fern Jour. 61: 171-182. [Study on *Thelypteris palustris, Woodwardia virginica,* and *Adiantum pedatum* in Washtenaw Co.]

Jordan, William Paul. 1973. The genus Lobaria in North America North of Mexico. Bryologist 76: 225-251. [*L. scrobiculata* apparently mapped from Isle Royale, although none of selected specimens cited are from Great Lakes region; two chemical races of *L. pulmonaria* and one of *L. quercizans* mapped at Michigan localities.]

Lewinsky, Jette. 1974. Some new or noteworthy mosses from west Greenland. Bryologist 77: 73-77. [Maps of world distribution of *Rhabdoweisia crispata* and *Isopterygium muellerianum* include Michigan localities.]

Manny, B. A., & R. G. Wetzel. 1973. Diurnal changes in dissolved organic and inorganic carbon and nitrogen in a hardwater stream. Freshwater Biol. 3: 31-43. [Study on Augusta Creek, Barry and Kalamazoo cos.]

Miller, Norton G. 1973. Lateglacial plants and plant communities in northwestern New York state. Jour. Arnold Arb. 54: 123-159. [Refers to several of the mosses as also occurring in Michigan Pleistocene deposits. Suggests that the beach pool–rich fen bryophyte communities along the Straits of Mackinac today "have had a long, probably continuous history" for here "the present zonation of the strand vegetation is similar to that which evidently existed in northwestern New York 12,000 years ago."]

Miller, Norton G. 1973. Pollen analysis of deeply buried Quaternary sediments from southern Michigan. Am. Midl. Nat. 89: 217-223. [A deposit in Clinton Co., over 32,000 years old, includes microspores of *Selaginella selaginoides* and pollen of other boreal forest species.]

Otsuki, Akira, & Robert G. Wetzel. 1972. Coprecipitation of phosphate with carbonates in a marl lake. Limnol. Oceanogr. 17: 763-767. [Data from Lawrence Lake, Barry Co.]

Otsuki, Akira, & Robert G. Wetzel. 1973. Interaction of yellow organic acids with calcium carbonate in freshwater. Limnol. Oceanogr. 18: 490-493. [Decomposition of *Scirpus subterminalis* from Lawrence Lake, Barry Co., by microflora was source of soluble humic substances removable with calcium carbonate.]

Otsuki, Akira, & Robert G. Wetzel. 1974. Calcium and total alkalinity budgets and calcium precipitation of a small hard-water lake. Arch. Hydrobiol. 73: 14-30. [Additional studies in Lawrence Lake, Barry Co.]

Peoples, Avery G., Jr. 1973. Biochemical evidence for the placement of Cetraria tuckermanii (Oakes) and Cetraria lacunosa (Ach) in the genus Platismatia. Mich. Academ. 6: 243-248. [All material analysed was from Marquette and Gogebic cos.]

Rich, Peter H., & Robert G. Wetzel. 1972. The benthic carbon budget of a southern Michigan marl lake. Verh. Internatl. Ver. Limnol. 18: 157-161. [Study in Lawrence Lake, Barry Co.]

Samuels, Gary J. 1973. The myxomyceticolous species of Nectria. Mycologia 65:401-420. [Michigan included in range of *N. candicans.*]

Schofield, W. B. 1972. Bryology in arctic and boreal North America and Greenland. Canad. Jour. Bot. 50: 1111-1133. [Maps of North American distribution of six species include Michigan localities.]

Stoutamire, Warren P. 1974. Relationships of the purple-fringed orchids Platanthera psycodes and P. grandiflora. Brittonia 26: 42-58. [Map shows *P. psycodes* throughout

Michigan; hybrids with *P. lacera* noted near Grand Marais, Michigan, with chromosome counts of 2n = 42 for hybrid and both parents.]

Thompson, Paul W., & James R. Wells. 1974. Vegetation of Manitou Island, Keweenaw County, Michigan. Mich. Academ. 6: 307-312. [Supplements report on the mainland of the county by the same authors in Mich. Bot. 13: 107-151 (May 1974). Includes list of 190 species collected on one July day by the authors and one June day by C. D. Richards.]

Thomson, John W. 1972. Distribution patterns of American arctic lichens. Canad. Jour. Bot. 50: 1135-1156. [Distribution map for *Icmadophila ericetorum* shows two localities in Michigan.]

Tryon, Alice, & Rolla Tryon. 1973. Thelypteris in northeastern North America. Am. Fern Jour. 63: 65-76. [Geographic, nomenclatural, cytological, and spore data—no descriptions or key. Reports quoted for chromosome numbers of *T. palustris* and *T. noveboracensis* determined from Michgian material.]

Vitt, Dale H. 1972. A monograph of the genus Drummondia. Canad. Jour. Bot. 50: 1191-1208. [*D. prorepens* cited from two Michigan localities.]

Walkinshaw, Lawrence H. 1973. A history of sandhill cranes on the Haehnle Sanctuary, Michigan. Jack-Pine Warbler 51: 54-74. [Includes description of the vegetation and map showing its distribution in this Jackson Co. sanctuary.]

Wentz, W. Alan, & Ronald L. Stuckey. 1971. The changing distribution of the genus Najas (Najadaceae) in Ohio. Ohio Jour. Sci. 71: 292-302. [Includes Michigan data for *N. marina* and *N. minor* (mapping the latter) and mentions that *N. gracillima* has been found in Michigan. See also pp. 181-185 in this issue.]

Wetzel, Robert G., Peter H. Rich, Michael C. Miller, & Harold L. Allen. 1972. Metabolism of dissolved and particulate detrital carbon in a temperate hard-water lake. Mem. Ist. Ital. Idrobiol. 29 Suppl.: 185-243. [Study in Lawrence Lake, Barry Co.]

Wetzel, Robert G. 1972. The role of carbon in hard-water marl lakes. Am. Soc. Limnol. Oceanogr. Spec. Symp. 1: 84-97. [Data mostly from Lawrence Lake, Barry Co.; considers role of aquatic macrophytes and microflora, including epiphytes.]

Wetzel, Robert G., & Bruce A. Manny. 1972. Secretion of dissolved organic carbon and nitrogen by aquatic macrophytes. Verh. Internatl. Ver. Limnol. 18: 162-170. [Includes observations on Lawrence Lake.]

Wetzel, Robert G., & Akira Otsuki. 1974. Allochthonous organic carbon of a marl lake. Arch. Hydrobiol. 73: 31-56. [Contains much data on Lawrence Lake, including spectral analyses.]

D. HISTORY, BIOGRAPHY, EXPLORATION

Finan, John J. 1972. Edgar Anderson 1897-1969. Ann. Missouri Bot. Gard. 59: 325-345. [Biography of noted 1918 graduate of Michigan State University, who had lived in East Lansing since the age of 3. Anderson's graduate training and professional life took place away from Michigan, but he frequently collected in the state. The same issue of the Annals includes a bibliography and other material about Anderson.]

Meyer, Frederick G., & Susanne Elsasser. 1973. The 19th century herbarium of Isaac C. Martindale. Taxon 22: 375-404. [Includes brief biographical data on Michigan collectors: Zina Pitcher, Douglass Houghton, John Wright.]

Peters, Bernard C. 1973. Settler attitudes toward the land as revealed in the pioneer poetry of Kalamazoo County. Mich. Academ. 6: 209-216. [Examines pioneer attitudes toward the "wilderness," which was to be subdued and "improved" by the white man. Although the author asserts that "the only land type to receive special attention from the poets was the prairie," he nevertheless cited "forest gloom," "oaken glade," "lay the forest prostrate," "war on the high-headed monarch of oak," "wrought from the forest the spoil of our beautiful fields"—none of which suggest prairies, especially in view of the author's earlier contention in another journal that "the Michigan pioneers never used the terms oak openings and prairies for the same landscape" (see Mich. Bot. 11: 46).]

Wagner, W. H., Jr. 1972. Notes and news. Am. Fern Jour. 62: 29. [Short obituary notice of Dale J. Hagenah, referring to the longer account in Mich. Bot. 11: 60-66 (March 1972).]

THE MICHIGAN BOTANIST is distributed not only to a considerable number of individual and institutional subscribers domestically and abroad, but also to all members of the Michigan Botanical Club, an organization composed in large part of non-professionals with concerns for conservation and nature study as well as the local flora. (Total paid circulation exceeds 1000). Considering the range of interests among members and subscribers, we seek to include (in each year if not each issue) the widest possible range of subject matter in regard both to the entire plant kingdom and to branches of the field of botany.

Articles should, in general, include some new botanical information, and should pertain to the Upper Great Lakes region. Not acceptable are manuscripts of primarily literary nature (including all poetry and articles of an "editorial" orientation). Notes on techniques useful to the teacher and hobbyist are welcomed, as is material of biographical and historical nature.

To promote clarity to non-technical readers (without sacrifice of accuracy and precision), such means are encouraged as illustrations, inclusion of a generally accepted "common name" (when such exists) at least once in the title or text of any article devoted to consideration of one or a few species, and introductory material placing the author's studies in perspective and briefly indicating their significance. Summaries, especially of long or complex papers, are desirable.

Manuscripts should be submitted to the editor in chief and are considered on their botanical merit and clarity of presentation; their acceptability is judged without special regard for repetition of authors, length, or prospect of subsidies. All manuscripts are subject to advisory review by botanists prepared to evaluate not only their content but also their suitability for this journal. Manuscripts are ordinarily published in the order of acceptance, with allowance as necessary for maintenance of diversity within our space limitations. In the interests of diversity, acceptable articles occupying more than 10 printed pages can be published only if divided into two or more issues or if the necessary additional pages can be subsidized (present charge is $20.00 per page). Subsidy of the entire cost of an acceptable article will permit its publication without delay, and authors with access to funds for this purpose are encouraged to allow complete subsidy, regardless of length of article, to avoid contributing toward a backlog of papers awaiting publication.

NOTE: Manuscripts should be *neatly* typed, with generous margins, double-spaced (including particularly bibliographies, figure legends, and other technical matter), and submitted in duplicate to simplify review. Use 8½ X 11 inch paper, and avoid "erasable" kinds! Please save the time of authors, editor, and printer by conscientiously following the style of current issues in regard to headings, identifications of authors beneath the title, citation of literature, abbreviations, and other matters of form. In "Literature Cited," only the name of the first author is inverted when there are two or more authors; if it is not desired to repeat an author's name, a long *dash* (not an underline) replaces it; if complete names of authors as in original publication are not used, then *all* names (except surname) should be consistently reduced to initials; and complete pagination should be indicated for all titles. An "&" rather than "and" is used in Literature Cited and all references in parentheses; italics are *not* used in Literature Cited; in titles of journal articles, only the first word and proper nouns (including names of genera and higher categories) are capitalized; all principal words are capitalized in names of journals and titles of books, bulletins, theses, and other non-journal articles. Check "Michigan Plants in Print" or current issues for examples of abbreviations and style. Illustrations and maps are encouraged so long as they can be reduced to page size (4½ X 7 inches); all are numbered consecutively as "Figures."

Page proof is sent to authors (at least in North America) and must be checked for errors and returned promptly; major revisions cannot be made at this time. Reprints (with extraneous matter removed) can be supplied at standard prices established by the printer (rate schedule available from the editor). An order form is supplied with proof.

—The Editorial Board

Editorial Notes

SUBSCRIPTIONS RISE. As already recorded on the inside front cover, inflation has forced us to increase our income. The costs of printing, paper, and postage are rising dramatically. Effective with Vol. 14 (1975) the annual subscription rate for THE MICHIGAN BOTANIST will be $5.00. (That will be eight years after the previous increase.) Members of the Botanical Club will continue to receive the journal as one of the privileges of membership, but membership dues will also have to rise. Back issues through Vol. 13 will remain at $3.00 per volume, when available. Page charges, for all pages in excess of 10 in any one article, have been raised to $20.00, effective with manuscripts received in February 1973.

The May number (Vol. 13, No. 3) was mailed May 22, 1974.

Publications of Interest

WISCONSIN SCIENTIFIC AREAS. Scientific Areas Preservation Council, Department of Natural Resources, Madison, Wisconsin 53701. 1973. 52 pp. Includes brief descriptions of the 104 natural areas designated as of April 1973, totaling 15,000 acres. A chart indicates which areas illustrate the various terrestrial and aquatic plant communities recognized in Wisconsin, and a colored map summarizes "Early Vegetation of Wisconsin." General introductory material on the scientific area program in the state includes highlights of 1970-1973, during which the Council staff investigated more than 300 natural areas, of which 55 were "actively considered"; 26 new areas were added to the state system. An excellent booklet, showing graphically what a state Department of Natural Resources can do with professional staff and biennial appropriation of $100,000 for the purchase of scientific areas.

ORNITHOLOGY AT THE UNIVERSITY OF MICHIGAN BIOLOGICAL STATION AND THE BIRDS OF THE REGION. By Olin Sewall Pettingill, Jr. Kalamazoo Nature Center, Spec. Publ. No. 1. 1974. 118 pp. $4.00. A revision and up-dating of the work of similar scope by Theodora Nelson, published in 1956. Includes historical background about the Biological Station in general and ornithology at the Station in particular, followed by thoroughly annotated list of birds of the region (Cheboygan and Emmet counties). Various plants are mentioned in notes on food, nesting materials, and of course habitat.

INDEX TO PLANT CHROMOSOME NUMBERS 1967-1971. Edited by R. J. Moore. Regnum Vegetabile Vol. 90. 1973. 539 pp. $25.00 ($16.60 for members of International Association for Plant Taxonomy). A computer-compiled cumulative volume covering the five years since the Russian compilation covering chromosome numbers published prior to 1967 (noted in Mich. Bot. 9: 207. 1970).

BIOLOGICAL NOMENCLATURE. By Charles Jeffrey. Special Topics in Biology Series. Edward Arnold Ltd., London. 1973. 69 pp. £1.00 (paper). A concise, lucid, and (happily!) accurate exposition of the provisions of the various codes of nomenclature used by biologists. Common principles and topics (e.g., names at the various ranks, stability, typification, priority, authorities and their citation) are considered in turn, noting any variations among the codes used by botanists, zoologists, and bacteriologists. Treatment of "special cases" (e.g., fossils, lichens, cultivated plants, hybrids) follows. The clarity of presentation should be helpful to persons having difficulty putting the subject of nomenclature into focus, but this book is not intended to be a substitute for the codes in practice.

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(On the cover: Sagina nodosa *("Pearlwort"),
an arctic-alpine species found on the north shore
of Lake Superior. Photo by Garrett E. Crow.)*

Vol. 14, No. 1

THE MICHIGAN BOTANIST

January, 1975

THE MICHIGAN BOTANIST—Published by the Michigan Botanical Club four times per year: January, March, May, and October. Second-class postage paid at Ann Arbor, Michigan.

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Back issues beginning with Vol. 14 are $5.00 per volume ($1.25 per number). Complete sets and sets beginning with Vol. 2 are available. On these, as on any order totalling 20 or more copies, a 25% discount is allowed.

Subscriptions (from those not members of the Michigan Botanical Club) and all orders for back issues should be addressed to the business and circulation manager.

Address changes from Botanical Club members should be sent only to appropriate chapter officers. Address changes for *non-member subscribers only* should be sent to the business and circulation manager. Send *no* address changes to the editor.

Articles dealing with any phase of botany relating to the Upper Great Lakes Region may be sent to the editor in chief. In preparing manuscripts, authors are requested to follow our style and the suggestions in "Information for Authors" (Vol. 13, p. 190).

THE MICHIGAN BOTANICAL CLUB

Membership in the Michigan Botanical Club is open to anyone interested in its aims: conservation of all native plants; education of the public to appreciate and preserve plant life; sponsorship of research and publication on the plant life of the State; sponsorship of legislation to promote the preservation of Michigan native flora and to establish suitable sanctuaries and natural areas; and cooperation in programs concerned with the wise use and conservation of all natural resources and scenic features.

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VASCULAR PLANTS OF PICTURED ROCKS NATIONAL LAKESHORE, ALGER COUNTY, MICHIGAN

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INTRODUCTION

Pictured Rocks National Lakeshore (referred to interchangeably below as park) is located in the eastern Upper Peninsula of Michigan on the southern shore of Lake Superior between the towns of Munising (on the west) and Grand Marais (on the east) in Alger County. (See Fig. 1.) The largest city in the Upper Peninsula, Marquette, lies 43 miles to the west. Authorization to create this National Lakeshore was granted to the Secretary of the Interior in 1966 and about 27,500 acres have since been purchased. An additional 39,000 acres have been included in the lakeshore but remain in private ownerships under a management agreement with the National Park Service. Further information on the National Lakeshore may be obtained from the official master plan (Feil et al., 1968).

As part of a comprehensive inventory of the natural features of the Pictured Rocks National Lakeshore requested by the National Park Service and carried out by the University of Michigan Biological Station, this report deals primarily with the botanical features of the approximately 27,500-acre federally owned shoreline zone. Only the vascular plants (i.e. pteridophytes and spermatophytes) have been catalogued in this report, which also includes discussion of the major vegetation types, the phytogeographical significance of certain plants found in the park, and a brief history of botanical interests in the park.

Six weeks were spent by me at two-week intervals in the summer of 1973 accumulating information on the botanical resources of the park. Because of the large area included in the National Lakeshore, I relied on three sources for determining what areas in the park should be emphasized for examination: 1) recommendations suggested by National Park Service personnel and others familiar with the area; 2) those areas in the park for which development plans have been made, including the route of the proposed shoreline drive; and 3) perusal of low flight aerial photographs for potentially interesting areas.

Most of the time spent in the park was utilized in making field inspections of areas throughout the park, taking notes on the vegetation, and making collections of representative plants. Due to the lack of assisting personnel and the limitations of time for the botanical study, only qualitative

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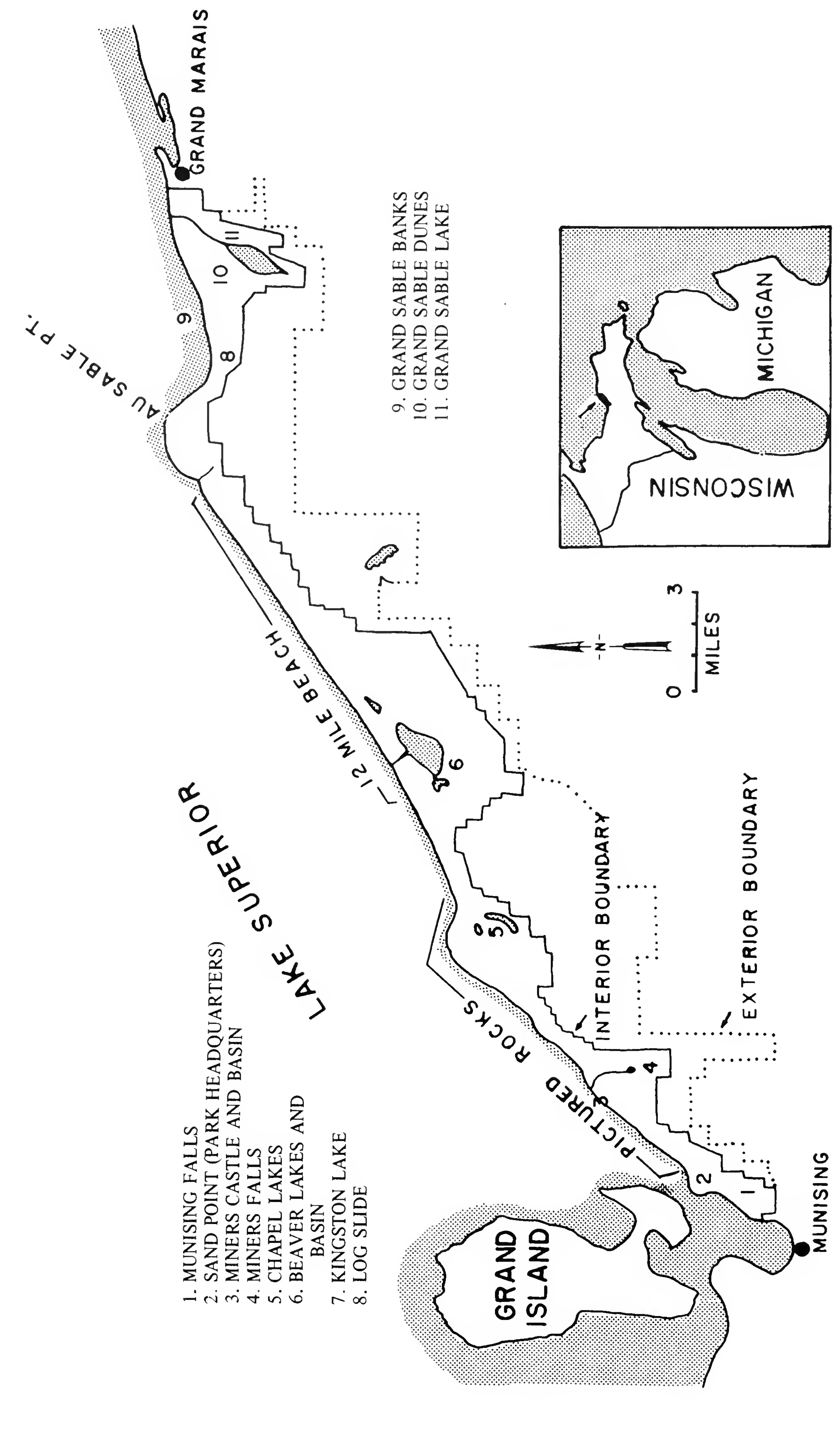

Fig. 1. Location map. Pictured Rocks National Lakeshore, Michigan.

statements concerning the abundance of particular species and the characterization of major vegetation types can be made.

A BRIEF HISTORY OF BOTANICAL EXPLORATION IN THE PICTURED ROCKS AREA

Since the early 1660's when the two French explorers Radisson and Groseilliers became the first known Europeans to see the Pictured Rocks and Grand Sable Banks (Thwaites, 1888), many later observers have commented on the grandeur of these two physiographic features. Most of the published accounts of the area since European discovery have been directed at describing the geological features, with attention to the vegetational characteristics getting only passing interest. For example, in the first organized scientific expedition passing the area, Henry Rowe Schoolcraft of the Cass Expedition of 1820 offered this as a typical observation of the flora:

> On the top of this entablature [the Doric Rock, which collapsed in 1906] rests a stratum of alluvial soil, covered with a handsome growth of pine and spruce trees, some of which appear to be fifty or sixty feet in height.

James Duane Doty, secretary of the 1820 Cass Expedition, gave probably the most consistently good descriptions of the arboreal vegetation which he saw on the trip. Writing of the species seen on the summit of the cliffs above the Doric Rock, however, he states only that "birch, beech & maple" grow along the top (Doty, 1895). Apparently the awesome sand and rock structures impressed the early travellers much more than the plants that grew among them.

Just as the botanical observations of the area were casual, so have been the actual collections of plants. The first known collections were a few made by Douglass Houghton on the Schoolcraft Expeditions of 1831 and 1832 (see Rittenhouse & Voss, 1962, for an account of the 1832 collections). Dr. Zina Pitcher, a physician stationed at Fort Brady (Sault Ste. Marie) in the late 1820's, was another of the early collectors in the area. His collection of *Cirsium pitcheri* (a thistle named in his honor) "on the great sand banks of Lake Superior" is the earliest collection of this plant from its sole Lake Superior station (see Guire & Voss, 1963, for discussion).

With the region's outstanding scenery it is hard to understand why the Pictured Rocks and Alger County in general have not attracted more serious botanical interest. In 1914-1917 Charles Keene Dodge, a Michigan lawyer turned professional botanist, spent much time in the eastern Upper Peninsula collecting plants. From his efforts came floras on Marquette County (Dodge, 1918b), just west of Alger County, and Schoolcraft County (Dodge, 1921), just east and south of Alger County. Dodge did collect in western Alger County (around Au Train Bay), and around Grand Marais and Munising, but he did not get into the interior of what is now the National Lakeshore. One must assume that the lack of botanical records in this area stems from the inaccessibility of many portions from towns, trails, railroads, or the water. That this is true is suggested by this passage regarding the occurrence of *Cryptogramma stelleri* in Michigan (Dodge, 1918a):

The Michigan Flora [Beal, 1905] reports it as found on Louise Isle and as seen by the late G. H. Hicks at the Pictured Rocks on the south shore of Lake Superior. In 1916 a visit was made to Grand Marais, Grand Island and Munising, and an attempt was made to reach the Pictured Rocks which lie between these two places. The old lumber roads and trails to the latter locality were found to be impassable, but at Munising conditions were more favorable and a search for the species was made at that place.

Despite even the present lack of good access to many portions of the National Lakeshore, a few people have added to the botanical knowledge of the area. In 1934 America's foremost 20th century taxonomist, M. L. Fernald, included the Pictured Rocks in the itinerary of his only trip to the upper Great Lakes region (Fernald, 1935). Other botanists of recent years who have explored various parts of what is now the National Lakeshore include Stanley A. Cain (1947), Frederick W. Case, John A. Churchill, Henry A. Gleason (1940), Frederick J. Hermann (1934), Rogers McVaugh, and Edward G. Voss. Still, Alger County and the Pictured Rocks area in particular remain among Michigan's botanically least known areas.

MAJOR VEGETATION TYPES IN THE PARK

The vegetation along the Lake Superior shoreline, the most attractive feature of the National Lakeshore, is strongly influenced by the moderating effects of the lake. The actual lake frontage may be divided into two types: beach strand-dune community and the sandstone cliff community. The beach strand-dune community is well developed on Sand Point, Miners Beach, Chapel Beach, Twelve Mile Beach, and the Grand Sable Dunes. These beaches contain an undiverse and predictable number of plants, dominantly grasses. (See Table I.)

As can also be seen in Table I, the number of species occurring on and restricted in the park to the Grand Sable Dunes is much higher than on the exposed Lake Superior beach. (See Fig. 2.)

One of the species listed in Table I has a well-defined range limit in Michigan within the park. Dune grass (*Elymus mollis*) has so far been recorded

TABLE I. Representative Species of Beach Strand and Dunes

Agropyron trachycaulum	Festuca saximontana*
Ammophila breviligulata	Juniperus communis var. depressa
Andropogon scoparius*	Lathyrus japonicus var. glaber
Arabis lyrata	Lithospermum croceum*
Artemisia caudata	Oenothera biennis
Cirsium pitcheri*	Prunus pumila
Corispermum hyssopifolium*	Salix cordata*
Deschampsia flexuosa	Salix interior
Elymus canadensis	Smilacina stellata*
Elymus mollis	Stellaria longipes*
Equisetum arvense	Tanacetum huronense*

*Indicates plants most commonly encountered or restricted in the park to Grand Sable Dunes.

Fig. 2. Grand Sable Banks and Dunes. These perched dunes, reaching up to 300 feet above the Lake Superior surface, are a unique feature on this Great Lake. The dunes possess habitats and plants found nowhere else in Pictured Rocks National Lakeshore (photo by R. H. Read).

on beaches only as far west as Chapel Beach. The total range in Michigan of this northern grass is restricted to beaches from Chapel Beach to Whitefish Point in Chippewa County (Voss, 1972).

Behind the beach strand immediately fronting Lake Superior there is usually a steep unstable slope known as a storm or winter beach. Depending on its exposure to the lake this zone may be collapsing sand or it may support more substantial stable vegetation. In the latter case the winter beach may bear light to medium cover of shrubs and stunted trees such as black spruce (*Picea mariana*), cherries (*Prunus* spp.), juneberries (*Amelanchier* spp.), blueberries and bilberries (*Vaccinum* spp.), mountain holly (*Nemopanthus mucronata*), Michigan holly (*Ilex verticillata*), and Labrador-tea (*Ledum groenlandicum*). Pines, hemlock, and balsam fir often occur on the upper edge of the winter beach where they frequently become dislodged from the level forested edge.

The groundlayer species of the winter beach are similar to the forest edge-lake interface above it, which often takes on a boreal aspect influenced by the cold microclimate produced by Lake Superior. Plants in this narrow zone are mainly of a northern affinity and commonly include Canada mayflower (*Maianthemum canadense*), bunchberry (*Cornus canadensis*), starflower (*Trientalis borealis*), goldthread (*Coptis groenlandica*), bluebead (*Clintonia* *borealis*), twinflower (*Linnaea borealis*), creeping snowberry (*Gaultheria hispidula*), wild sarsaparilla (*Aralia nudicaulis*), trailing arbutus (*Epigaea repens*), and various species of ferns and lycopodiums.

The forest above the winter beach is on sandy soil and is invariably dominated by conifers. On Sand Point, on the embayments of Miners and Chapel Basin, and along portions of Twelve Mile Beach the dominant conifers are red, white, and jack pines (*Pinus resinosa, P. strobus,* and *P. banksiana,* respectively). However on portions of Twelve Mile Beach large hemlocks (*Tsuga canadensis*) mixed with balsam fir (*Abies balsamea*) and white spruce (*Picea glauca*) front on Lake Superior. The reason for this major difference in tree vegetation in seemingly comparable soils and microclimate is not known.

Only a handful of species are to be found on the vertical cliff faces (see Fig. 3) and sloping sandstone bases of the Pictured Rocks. Butterwort (*Pinguicula vulgaris*) and bird's-eye primrose (*Primula mistassinica*) are common species of shaded to open cliffs while the small flowered grass-of-parnassus (*Parnassia parviflora*) is occasionally found in cracks along the base of the cliffs and on horizontal bedrock. A characteristic species of the exposed cliffs is the green or mountain alder (*Alnus crispa*) which often grows with such companion shrubs and trees as willows, Labrador-tea, showy

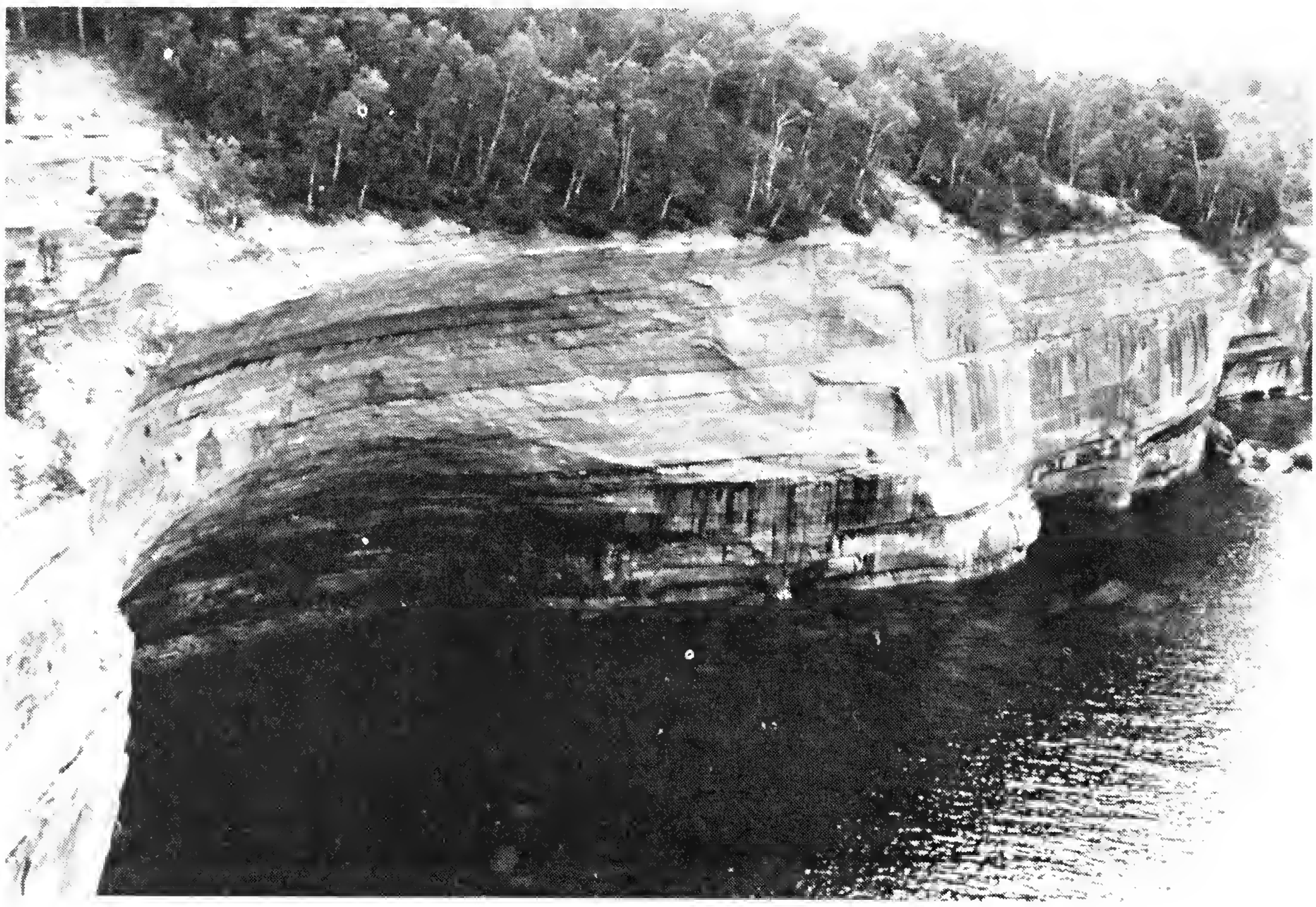

Fig. 3. Sheer Cliffs of the Pictured Rocks. Such scenery impressed James Doty of the 1820 Cass Expedition more than "... the Cataract of Niagara." This photograph taken from Grand Portal Point toward the west is typical of the 200- to 300-foot faces of exposed sandstone. Loose, moving sand is often present on the summits of the cliffs, and birch-beech-sugar maple forests usually hug the precipitous edges (photo by R. H. Read).

mountain-ash (*Sorbus decora*), *Vaccinium ovalifolium,* and *Vaccinium membranaceum.*

The top edge of the exposed Pictured Rocks escarpment is often very shrubby with the above-mentioned species plus others such as beaked hazelnut (*Corylus cornuta*), and gooseberries and currants (*Ribes* spp.). Often, however, the top of the sandstone cliffs have been eroded away by the wind, causing "mini-sand dunes" two hundred feet above the Lake Superior surface! These small dunes are usually devoid of vegetation but are interesting in that active sand movement covers and uncovers the adjacent forest edge, leaving a "graveyard" tree zone near the summit of the cliffs.

Practically without exception the forest on top of the Pictured Rocks escarpment is beech (*Fagus grandifolia*)—sugar maple (*Acer saccharum*) mesic forest. Why mesic deciduous woodland should predominate in such a situation can probably be explained by the thin limestone cap covering the sandstone bedrock. The resultant calcareous edaphic conditions and the slow vertical percolation of water favor climax forest types over the predominant pineland of the sandy, well-drained embayments and outwash plains.

The deciduous woodland is the dominant forest type in the park. Like most plant communities its composition depends on local moisture gradients, ranging from dry well-drained sites to wet seeping areas. In this portion of the state the deciduous woodland often more accurately becomes a mixed conifer-deciduous forest, since certain conifers (namely hemlock and white spruce) often make up a substantial part of the dominant trees in particular areas. Throughout the park hemlock may be found in groves on level ground and well-drained sites, their large size often giving one the feeling of entering an outdoor cathedral.

Undoubtedly the richest wooded areas in the park are where the Pictured Rocks escarpment swings inland away from Lake Superior behind Sand Point, at Miners Basin, at the Chapel Lake area, and near Sable Falls. At the base of the shaded cliffs and in deep short ravines fed by seep water from above grow many rich deciduous forest and cliff fern species, some found rarely elsewhere in the park but in these habitats.

Mid-May to early June is the best time for visitors to see the ephemeral spring flora of the deciduous forest. (See Table II for characteristic species of this forest type.)

On the sandy soils of the embayments and on inland outwash plains open pine barrens or thinly wooded pine forests are typically found. Miners Basin is the outstanding example in the park of a predominantly jack pine embayment area, while Sand Point supports very large red and white pines on gently undulating beach ridges. These two examples seem to have escaped much of the heavy logging pressure which the other pine forested areas have sustained. Additionally, only Miners Basin has so far escaped most of the surface damage caused by off-the-road vehicles, damage which is becoming more common and is noticeable years after the fact.

The understory species of the pine woodland include a characteristic group of species. Most notable are the blueberries, bracken fern (*Pteridium*

TABLE II. Representative Species of Deciduous Woods

DOMINANT TREE SPECIES

Acer pensylvanicum	Fagus grandifolia
Acer saccharum	Ostrya virginiana
Acer spicatum	Tilia americana
Betula alleghaniensis	Tsuga canadensis

REPRESENTATIVE GROUNDLAYER SPECIES

Actaea pachypoda	Maianthemum canadense
Actaea rubra	Milium effusum
Allium tricoccum	Mitchella repens
Aralia nudicaulis	Mitella nuda
Arisaema triphyllum	Osmorhiza claytonii
Aster macrophyllus	Osmorhiza obtusa
Botrychium virginianum	Oxalis montana
Caulophyllum thalictroides	Polygonatum pubescens
Claytonia caroliniana	Prenanthes alba
Clintonia borealis	Sambucus pubens
Dentaria diphylla	Sanicula marilandica
Dicentra canadensis	Smilacina racemosa
Dicentra cucullaria	Streptopus roseus var. longipes
Dryopteris spinulosa	Taxus canadensis
Epifagus virginiana	Trillium grandiflorum
Erythronium americanum	Viola canadensis
Galium triflorum	Viola pubescens
Lycopodium lucidulum	

TABLE III. Representative Species of Pine Woods and Barrens

DOMINANT TREE SPECIES

Acer rubrum	Pinus strobus
Amelanchier spp.	Populus grandidentata
Betula papyrifera	Populus tremuloides
Picea glauca	Prunus pensylvanica
Pinus blanksiana	Quercus rubra
Pinus resinosa	

REPRESENTATIVE GROUNDLAYER SPECIES

Anaphalis margaritacea	Gaultheria procumbens
Apocynum androsaemifolium	Gaylussacia baccata
Aralia hispida	Hieracium spp.
Aralia nudicaulis	Maianthemum canadense
Arctostaphylos uva-ursi	Melampyrum lineare
Aster macrophyllus	Oenothera biennis
Chimaphila umbellata	Polygala paucifolia
Corylus cornuta	Pteridium aquilinum
Cynoglossum boreale	Rubus allegheniensis
Cypripedium acaule	Spiranthes lacera
Diervilla lonicera	Vaccinium angustifolium
Epigaea repens	Vaccinium membranaceum
Epilobium angustifolium	Vaccinium ovalifolium
Erigeron spp.	Vaccinium myrtilloides
Fragaria virginiana	

aquilinum), the stemless lady's slipper (*Cypripedium acaule*), and huckleberry (*Gaylussacia baccata*). (See Table III for other common species.)

Lowland areas in the park are most characteristically forested with white-cedar (*Thuja occidentalis*), black spruce (*Picea mariana*), tamarack (*Larix laricina*), balsam fir (*Abies balsamea*), and black ash (*Fraxinus nigra*). Such associations are most often found in poorly drained low areas, in shallows of sand deposition areas (as on Au Sable Point) and in low areas adjacent to lakes and streams. (See Table IV for dominant species in such habitats.)

On upland areas adjacent to large lowlands and lakes one comes closest to finding the boreal forest type more characteristic of Canada. In this community type, conifers [i.e. balsam fir, white spruce, white-cedar, and white pine] are the dominant tree species. This association of trees with the accompanying groundlayer species (*Aralia nudicaulis, Gymnocarpium dryopteris, Melampyrum lineare, Cornus canadensis, Galium triflorum, Maianthemum canadense,* etc.) of the boreal forest is not common in Pictured Rocks National Lakeshore but may be most closely approximated in areas on and behind Au Sable Point, and on the narrow exposed zone facing Lake Superior discussed above as "winter beach."

Along stream floodplains and around some small lakes and ponds may be found thickets of alder (*Alnus rugosa*). This minor plant community contains much the same herbaceous species that are encountered in conifer lowland forests. Several examples of alder thickets in the park include Sand

TABLE IV. Representative Species of Wet Woods (Dominantly Conifer)

DOMINANT TREE SPECIES	
Abies balsamea	Larix laricina
Alnus rugosa	Picea mariana
Betula alleghaniensis	Thuja occidentalis
Fraxinus nigra	
REPRESENTATIVE GROUNDLAYER SPECIES	
Aralia nudicaulis	Linnaea borealis
Carex canescens	Maianthemum canadense
Carex disperma	Matteuccia struthiopteris
Carex leptalea	Mitella nuda
Carex pauciflora	Moneses uniflora
Carex trisperma	Nemopanthus mucronata
Circaea alpina	Onoclea sensibilis
Clintonia borealis	Osmunda cinnamomea
Coptis groenlandica	Osmunda claytoniana
Cornus canadensis	Osmunda regalis var. spectabilis
Gymnocarpium dryopteris	Oxalis montana
Dryopteris phegopteris	Ribes lacustre
Gaultheria hispidula	Ribes triste
Habenaria obtusata	Rubus pubescens
Ilex verticillata	Smilacina trifolia
Impatiens capensis	Trientalis borealis
Ledum groenlandicum	Viola macloskeyi spp. pallens
Listera convallarioides	

Point near the base of the escarpment, between Arsenault Lake and Little Beaver Lake, and on the south side of Grand Sable Lake.

Wet unforested areas in the park are restricted to bogs and marshes. Bogs are usually filled-in lake beds having a sphagnum base and chiefly containing ericaceous shrubs such as leatherleaf (*Chamaedaphne calyculata*), bog rosemary (*Andromeda glaucophylla*), bog laurel (*Kalmia polifolia*), and cranberries (*Vaccinium macrocarpon* and *Vaccinium oxycoccos*). Four major bog areas have been located in the park: a very shrubby one on Sand Point, a filled-in bog northeast of Big Beaver Lake, several bog pockets around Legion Lake, and a classical bog lake east of Twelve Mile Beach campground (Au Sable campground).

Marshes are found primarily around the borders of lakes and contain a diverse number of species, especially in the sedge family. The best examples of marshes occur in quiet shallow pockets of large lakes and around the periphery of small lakes, most notably around Miners Lake and Little Chapel Lake.

A very minor plant habitat in the park but one containing many interesting plants is the wet sand beach flats found around the two large inland lakes of the park, Grand Sable and Big Beaver. The north side of Big Beaver Lake is the better of the two in this respect containing such plants as *Lycopodium inundatum, Aster nemoralis, Potentilla anserina, Juncus pelocarpus,* and *Utricularia cornuta.*

The submerged aquatic habitats of lakes, ponds, rivers and streams are extremely varied in their vegetational composition, so much so that to try to characterize them would practically necessitate describing the vegetation of each body of water. Comments regarding particular distributions of species are made in the catalogue of plants; interested readers are referred to such hydrophytic families as the Potamogetonaceae and Haloragaceae.

A particularly diverse set of lakes. easily accessible and each containing largely different sets of plants although connected by a narrow navigable channel, are Big and Little Beaver Lakes. In the sandy shallow water of Big Beaver Lake such interesting plants as quillwort (*Isoëtes muricata*), several water-milfoils (*Myriophyllum alterniflorum* and *M. tenellum*), and creeping spearwort (*Ranunculus reptans*) are found; while in Little Beaver Lake such uncommon park plants as *Potamogeton obtusifolius,* water star-grass (*Heteranthera dubia*), and American and narrow-leaved bur-reed (*Sparganium americanum* and *S. angustifolium,* respectively) may be seen. Due to difficult boat access most lakes in the park still lack sufficient information on their plant life.

SIGNIFICANCE OF THE FLORA OF PICTURED ROCKS NATIONAL LAKESHORE

While many of the plants found in Pictured Rocks National Lakeshore belong to either the eastern North American deciduous forest or the northern coniferous forest, certain plants found in the park have noteworthy distributions, at least in the context of their ranges in the upper Great Lakes region.

Some of the plants have decidedly boreal ranges (often extending into northern Asia and Europe) which dip only sporadically into upper Michigan and Wisconsin. Among such plants are black crowberry (*Empetrum nigrum*), butterwort (*Pinguicula vulgaris*), dune grass (*Elymus mollis*), Lake Huron tansy (*Tanacetum huronense*), holly fern (*Polystichum lonchitis*), *Pyrola minor, Mertensia paniculata,* and *Trisetum spicatum.*

A number of plants which occur in the park have their main range in the mountains of the western United States but have disjunct populations largely around the upper Great Lakes. These plants most likely extended east along the southern border of the last glaciers some nine to ten thousand years ago after which time climatic changes exterminated intermediate populations and isolated the plants in the upper Great Lakes region. To this interesting group belong trail-plant (*Adenocaulon bicolor*), striped coral-root (*Corallorhiza striata*), thimbleberry (*Rubus parviflorus*), *Crataegus douglasii, Goodyera oblongifolia, Vaccinium ovalifolium, Melica smithii,* and *Festuca occidentalis.*

Two plants found in the Grand Sable Dunes and on Lake Superior sand beaches are also found on ocean beaches as well as on beaches throughout the Great Lakes region. These two plants, marram or beach grass (*Ammophila breviligulata*) and beach pea (*Lathyrus japonicus*), are common dune and beach plants along the park shoreline. Not as widely distributed as these plants is the interesting and beautiful sand or Pitcher's thistle (*Cirsium pitcheri*). This plant is endemic to the sandy Great Lakes shorelines, and while widely distributed on Lakes Huron and Michigan, its only station on Lake Superior is on the Grand Sable Dunes, where it is locally common.

While the current study has found Pictured Rocks National Lakeshore to possess 572 species (of which 88% may be classed as native) some seemingly common plants in this area of the state could not be located in the park. Among such plants are *Halenia deflexa, Petasites palmatus,* and *Lobelia dortmanna.* Certainly within the total range of a plant there are areas of local abundance and rarity, so hopefully in the future obvious gaps in the known flora of the park will be filled in by observant botanists.

In noting absence or rarity of particular native plants and the abundance of weeds in the park (about 12% in this catalogue) one must contemplate the effect the large scale lumber industry has had on the native flora. An important fact to realize is that essentially all of the park's forests have been logged since the turn of the century with only very small and isolated enclaves of virgin timber remaining intact. An economic study of the proposed park done in 1963 by the Institute for Community Development, Continuing Education Service, Michigan State University, stated that the records of most former landowners showed that clear-cutting of forest lands occurred on most tracts within the last sixty years. The myriad of logging roads in the park seen best from aerial photographs and felt best by walking through thousands of acres of uniformly pole-size timber attest well to the thoroughness of the lumbering process. It is difficult to assess how great a change such land use has had on the presettlement vegetation of a century ago.

ANNOTATED CATALOGUE OF VASCULAR PLANTS OF PICTURED ROCKS NATIONAL LAKESHORE

Following is a catalogue of the vascular plants of Pictured Rocks National Lakeshore. Entries in the catalogue are based on one or more of the following sources. Many of the entries are based on plants seen by the author in the park during the summer of 1973, and in most cases at least one representative specimen was collected for deposit in the University of Michigan Herbarium [MICH]. Other entries are based on specimens seen by me in MICH, while others are based on specimens deposited at other herbaria for which there is a record in the Michigan Flora project files at MICH. Anyone desiring more specific information as to the source of a particular entry is urged to contact me, or E. G. Voss at the University of Michgian Herbarium.

A few of the species listed are based on sight records only, but these were kept to a minimum and limited to unmistakable species. Such entries not based on vouchered specimens are marked with an asterisk (*).

Also included in a few cases are collections of plants by early collectors made in the vicinity of Grand Marais or Munising, the actual sites of which may or may not be within the park boundaries, but these species can be expected to occur in the park. Some collections by the author and other recent collectors were made in the buffer zone of the park, as for example around Kingston Lake, and they are included due to their close proximity to the inner shoreline zone.

The catalogue is arranged alphabetically by scientific name of family, and within each family alphabetically by genus. Common names have been given when appropriate and widely used. Not all locally used common names could be listed for plants but only widely used ones, this judgment made by the author.

Scientific nomenclature of the gymnosperms and monocots is based on Voss, 1972. Nomenclature of the ferns, fern allies, and dicots adheres mainly to Fernald, 1950, and in some cases to Gleason and Cronquist, 1963. Where nomenclature significantly departs from Fernald an attempt has been made to cross-list Gray's Manual usage with the nomenclature preferred in the list.

One of the anticipated goals of such a catalogue is to motivate people to observe the plants around them. For the amateur botanist it provides a handle to learn what plants occur in the area; for the experienced or professional botanist it provides a challenge to fill in the gaps and oversights made by the author. I wish that this list should provide handles and challenges for all who use it.

NOTE: Several terms used in this catalogue should be explained. The *winter* or *storm beach* refers to the steeply inclined slope between the horizontal sand beach and the higher, level upland along Lake Superior. *Mixed woodland* refers to wet-mesic to dry-mesic forests covered with more or less equal numbers of deciduous and coniferous trees. The *escarpment* refers to the sandstone cliffs of the Pictured Rocks as well as the inland, shaded cliffs of the same geological feature, as it occurs for example around Miners Basin. See Figure 1 for the location of important geographical features mentioned in the catalogue. Asterisks (*) refer to unvouchered sight records.

ACERACEAE (MAPLE FAMILY)

Acer pensylvanicum L. STRIPED MAPLE, MOOSEWOOD.
An understory shrub-tree in rich, shaded deciduous forest.

Acer rubrum L. RED MAPLE.
Common in wet to dry woods.

*Acer saccharum Marsh. SUGAR MAPLE.
The codominant tree of the deciduous forest.

Acer spicatum Lam. MOUNTAIN MAPLE.
Occasional to common shrub or small tree in rich protected habitats.

ALISMACEAE (WATER-PLANTAIN FAMILY)

Sagittaria cuneata Sheldon. ARUM-LEAVED ARROWHEAD.
Collected on the south side of Chapel Lake, seen in L. Beaver Lake.

Sagittaria latifolia Willd. COMMON ARROWHEAD.
Common on the edges of rivers and lakes.

ANACARDIACEAE (CASHEW FAMILY)

Rhus radicans L. POISON-IVY.
Fortunately restricted to sandy areas on and around the Grand Sable Dunes.

APIACEAE (see Umbelliferae)

APOCYNACEAE (DOGBANE FAMILY)

Apocynum androsaemifolium L. SPREADING DOGBANE.
Found in dry semi-open areas.

Vinca minor L. PERIWINKLE.
Collected around the foundation of old resort on Miners Beach.

AQUIFOLIACEAE (HOLLY FAMILY)

Ilex verticillata (L.) Gray. MICHIGAN HOLLY.
In a variety of habitats, from swamps, stream and lake borders, to winter beaches of Lake Superior.

Nemopanthus mucronata (L.) Trel. MOUNTAIN HOLLY.
A common species of swamps and on winter beach of Lake Superior.

ARACEAE (ARUM FAMILY)

Acorus calamus L. SWEET-FLAG.
Occasional in shallow marshes, collected or observed in Little Chapel Lake and Miners Lake.

Arisaema triphyllum (L.) Schott. JACK-IN-THE-PULPIT.
Common in rich deciduous woods.

*Calla palustris L. WATER ARUM.
Seen only in semi-shaded bog area in vicinity of small lakes on Sand Point.

ARALIACEAE (GINSENG FAMILY)

Aralia hispida Vent. BRISTLY SARSAPARILLA.
Found in open to semi-open sandy pine barrens and woods.

*Aralia nudicaulis L. WILD SARSAPARILLA.
A common plant in a variety of habitats such as deciduous woods, pinelands, etc.

Aralia racemosa L. SPIKENARD.
Found in rich deciduous woodland, most frequently in protected areas such as below the shaded escarpment.

ASCLEPIADACEAE (MILKWEED FAMILY)

Asclepias syriaca L. COMMON MILKWEED.
Disturbed sandy roadsides.

ASTERACEAE (see Compositae)

BALSAMINACEAE (TOUCH-ME-NOT FAMILY)

Impatiens capensis Meerb. ORANGE JEWELWEED.
Not uncommon in shaded boggy places and stream borders.

BERBERIDACEAE (BARBERRY FAMILY)

Caulophyllum thalictroides (L.) Michx. BLUE COHOSH.
Local in rich deciduous woods.

BETULACEAE (BIRCH FAMILY)

Alnus crispa (Ait.) Pursh. GREEN OR MOUNTAIN ALDER.
A rather common shrub on exposed sandstone shores of Lake Superior.

*Alnus rugosa (DuRoi) Spreng. SPECKLED ALDER.
The common alder of extensive inland swampland. Abundant at such places as Little Beaver Lake, Sand Point (small lakes), and generally throughout park along water-courses and lakes.

Betula alleghaniensis Britt. [=Betula lutea Michx. f. in Gray's Manual]. YELLOW BIRCH.
A common element of the deciduous woodland, especially in damp and highly mesic situations.

Betula papyrifera Marsh. PAPER BIRCH.
Common in all types of upland habitats, sometimes forming dense stands of considerable beauty.

*Betula pumila L. DWARF BIRCH.
A species of open bogs and marsh thickets.

Corylus cornuta Marsh. BEAKED HAZELNUT.
A common thicket shrub of forest edges.

*Ostrya virginiana (Mill.) K. Koch. IRONWOOD.
A characteristic species of rich deciduous woods.

BORAGINACEAE (BORAGE FAMILY)

Cynoglossum boreale Fern. WILD COMFREY.
Occasional in shaded pineland or mixed woods.

Cynoglossum officinale L. HOUND'S TONGUE.
A rare weed collected and seen only at the Log Slide.

Lithospermum croceum Fern. [=L. caroliniense (Walt.) MacM. of Gleason and Cronquist]. HOARY PUCCOON.
Common but apparently restricted to the sand dunes of the Grand Sable Dunes.

Mertensia paniculata (Ait.) G. Don.
Uncommon in springy cedar slopes in the vicinity of Chapel Lake. This is the first record of this plant in the Pictured Rocks area, a species which has a range barely south into northern Michigan.

*Myosotis scorpioides L. COMMON FORGET-ME-NOT.
This plant is known from woods just east of Grand Marais. It undoubtedly occurs in the park also, but no collections were made, only sight records.

Myosotis sylvatica Hoffm. GARDEN FORGET-ME-NOT.
A common species of open damp to dry places, especially common near concession stand at Miners Castle.

BRASSICACEAE (see Cruciferae)

CALLITRICHACEAE (WATER STARWORT FAMILY)

Callitriche hermaphroditica L. WATER STARWORT.
A small aquatic plant, growing in shallow water (ca. 6″). Collected from Little Beaver and Grand Sable Lakes.

Callitriche verna L. WATER STARWORT.
Growing in shallow-water environments, such as in puddles of old trail roads (near Little Beaver L.) and in protected areas of larger lakes (as in Grand Sable Lake).

CAMPANULACEAE (BLUEBELL FAMILY)

Campanula aparinoides Pursh. MARSH BELLFLOWER.
Occasional in marsh areas. Collected only near Miners Lake.

CAPRIFOLIACEAE (HONEYSUCKLE FAMILY)

Diervilla lonicera Mill. BUSH HONEYSUCKLE.
A common species in a variety of habitats: dry to wet-mesic woods, and openings.

*Linnaea borealis L. TWINFLOWER.
Very common in wet woods such as cedar swamps but also forming large mats above the winter beach of Lake Superior.

Lonicera canadensis Bartr. AMERICAN FLY HONEYSUCKLE.
A common species in most types of lowland to upland woods.

Lonicera dioica L. RED HONEYSUCKLE.
Occasional in various woodland types usually near borders.

Lonicera morrowii Gray. MORROW'S HONEYSUCKLE.
Weedy bush around old buildings on Sand Point.

Sambucus canadensis L. ELDERBERRY.
Just east of Miners River north of M-94 bridge, in the park buffer zone; not seen elsewhere.

Sambucus pubens Michx. RED-BERRIED ELDER.
A common species in mixed to deciduous rich woods.

Viburnum cassinoides L. WITHE ROD.
A locally common species in open swamps northeast of Big Beaver Lake.

Viburnum lentago L. NANNYBERRY.
Seen and collected only on the margin of the bog behind Sand Point.

CARYOPHYLLACEAE (PINK FAMILY)

Cerastium vulgatum L. MOUSE-EAR CHICKWEED.
A locally common weed, most often in damp sandy places.

Lychnis alba Mill. WHITE CAMPION.
An occasional weed on sand dunes and on roadsides.

Silene cucubalus Wibel. BLADDER CAMPION.
A weed of disturbed ground, along roadsides and on sand dunes.

Stellaria calycantha (Ledeb.) Bong. STARWORT.
Occasional in swampy thickets.

Stellaria longipes Goldie. STARWORT.
Common on the Grand Sable Dunes and seemingly restricted to them. The state distribution is rather restricted for this small plant, rather puzzling in view of its commonness on the Grand Sable Dunes.

CERATOPHYLLACEAE (HORNWORT FAMILY)

Ceratophyllum echinatum Gray. SPINY HORNWORT.
Grand Sable Lake. Floating fragments collected. Scarce.

CHENOPODIACEAE (LAMB'S QUARTERS FAMILY)

Chenopodium album L. LAMB'S QUARTERS.
A very occasional weed in disturbed places.

Corispermum hyssopifolium L. COMMON BUGSEED.
Collected on the Grand Sable Dunes.

CISTACEAE (ROCKROSE FAMILY)

Hudsonia tomentosa Nutt. FALSE HEATHER.
Common on beach ridges and dunes.

COMPOSITAE (COMPOSITE FAMILY)

Achillea millefolium L. YARROW.
In a variety of disturbed to semi-disturbed habitats, such as sandy roadsides and sandstone cliffs. This taxon here included in the wide sense (including *A. lanulosa*).

Adenocaulon bicolor Hook. TRAIL-PLANT.
Occasional throughout park in very rich mixed woods, often near escarpments. A species of the West with a disjunct range in the upper Great Lakes region.

Ambrosia psilostachya DC. var. coronopifolia (T. & G.) Farwell. WESTERN RAGWEED.
In disturbed sandy areas throughout park.

Anaphalis margaritacea (L.) B. & H. PEARLY EVERLASTING.
Found throughout park in disturbed open or partially shaded ground.

Antennaria neodioica Greene. SMALL PUSSY TOES.
Encountered very infrequently in shaded disturbed ground.

Arctium minus (Hill) Bernh. COMMON BURDOCK.
Found in greatly disturbed areas such as former logging camp sites.

Artemisia absinthium L. COMMON WORMWOOD.
In disturbed areas such as roadsides and populated areas (e.g. Miners Castle concession stand).

Artemisia caudata Michx. BEACH WORMWOOD.
Common in sandy dune areas, especially on Grand Sable Dunes.

Aster junciformis Rydb. RUSH ASTER.
In a variety of damp open to semi-shaded areas.

Aster lateriflorus (L.) Britton. SIDE-FLOWERING ASTER.
In deciduous woodlands.

Aster macrophyllus L. BIG-LEAVED ASTER.
Common throughout park in a variety of dry wooded areas.

Aster nemoralis Ait. BOG ASTER.
Found only on sand flats on the north side of Big Beaver Lake. This station is currently the westernmost site in the range of this species in Michigan.

Aster puniceus L. SWAMP ASTER.
Common in wetland throughout park.

Aster umbellatus Mill. FLAT-TOP ASTER.
Occasional to common in wet areas throughout park.

Aster simplex Willd. PANICLED ASTER.
In a variety of habitats throughout park, from disturbed open areas to wetland.

Centaurea maculosa Lam. SPOTTED KNAPWEED.
A common weedy species along sandy and gravelly roadsides.

*Chrysanthemum leucanthemum L. var. pinnatifidum Lecoq. & LaMotte. OX-EYE DAISY.
An abundant weed of roadsides and fields.

Cirsium arvense (L.) Scop. CANADA THISTLE.
A weed along roadsides.

Cirsium palustre (L.) Scop.
An unfortunately common weed in disturbed damp to wet places, such as roadsides and old logging trails.

Cirsium pitcheri (Torr.) T. & G. SAND THISTLE.
Fairly common on the Grand Sable Dunes, the species' only confirmed station on the shores of Lake Superior. (See Guire and Voss, 1963.)

Cirsium vulgare (Savi) Tenore. BULL THISTLE.
An uncommon weed along roadsides.

Conyza canadensis. (See Erigeron canadensis).

Erigeron annuus (L.) Pers. ANNUAL FLEABANE.
Found in sandy open areas.

Erigeron canadensis L. [=Conyza canadensis]. HORSEWEED.
A weedy species of sandy open areas.

Erigeron strigosus Muhl. DAISY FLEABANE.
In habitats like the previous two species and in sandy woods.

Eupatorium maculatum L. SPOTTED JOE PYE WEED.
Found on sandy lakeshores, in marshes and various wet open habitats.

*Eupatorium perfoliatum L. COMMON BONESET.
Found in various wet habitats such as stream and lakeshores, and in marshes.

Eupatorium rugosum Houtt. WHITE SNAKEROOT.
Occasional in mixed rich woods and openings in the Chapel Lake and Miners Basin areas.

Heliopsis helianthoides (L.) Sweet. FALSE SUNFLOWER.
Found in open fields and along roads.

Hieracium aurantiacum L. ORANGE HAWKWEED.
Occasional to common in sandy openings, especially with a disturbance history.

Hieracium canadense Michx. CANADA HAWKWEED.
Found on stabilized partially shaded dunes.

Hieracium florentinum All. KING DEVIL.
An abundant weed in many disturbed habitats.

Hieracium scabrum Michx. ROUGH HAWKWEED.
An occasional weed in sandy places.

Lactuca floridana (L.) Gaertn. BLUE LETTUCE.
Found along roadsides, in fields and along forest edges.

Lapsana communis L. NIPPLEWORT.
A rare weed in Michigan, found growing along a trail near Miners Falls.

Matricaria matricarioides (Less.) Porter. PINEAPPLE WEED.
A common weed in parking lots and on roadsides.

Megalodonta beckii (Torr.) Greene. WATER-MARIGOLD.
An occasional aquatic plant of most lakes.

Prenanthes alba L. WHITE LETTUCE.
A common species in wet-mesic to mesic woods.

Rudbeckia hirta L. [incl. Rudbeckia serotina Nutt.] BLACK-EYED SUSAN.
An occasional species of fields and roadsides.

Solidago canadensis L. TALL GOLDENROD.
A species found in damp to dry openings.

Solidago graminifolia (L.) Salisb. GRASS-LEAVED GOLDENROD.
Found in damp sandy stream sides and openings.

Solidago hispida Muhl. WHITE GOLDENROD.
Common in sandy fields and dunes.

Solidago randii (Porter) Britton.
High dunes of the Grand Sable Banks.

Solidago rugosa Ait. ROUGH GOLDENROD.
Collected on sand ridges under pines on Sand Point.

Solidago uliginosa Nutt. BOG GOLDENROD.
Common in bog mats and marshes.

Sonchus uliginosus Bieb. SMOOTH SOW-THISTLE.
An occasional roadside and field weed.

Tanacetum huronense Nutt. LAKE HURON TANSY.
Apparently restricted to the Grand Sable Dunes where it is common.

Tanacetum vulgare L. TANSY.
An uncommon weed in openings of old residences and camps.

Taraxacum officinale Weber. DANDELION.
A common weed in lawns and openings.

Tragopogon dubius Scop. [= T. major]. GOAT'S-BEARD.
A weed species of sandy roadsides and fields.

CORNACEAE (DOGWOOD FAMILY)

Cornus alternifolia L. f. PAGODA DOGWOOD.
An infrequent species of rich deciduous woodland.

Cornus canadensis L. BUNCHBERRY.
An abundant plant along the winter beach and back shoreline of Lake Superior, commonly under conifers.

Cornus stolonifera Michx. RED-OSIER DOGWOOD.
A shrub of open wet areas, but also found on sandy dune uplands.

CORYLACEAE (see Betulaceae)

CRASSULACEAE (ORPINE FAMILY)

Sedum acre L. WALL-PEPPER.
A small weed of damp sand.

CRUCIFERAE (MUSTARD FAMILY)

Arabis glabra (L.) Bernh. TOWER MUSTARD.
Not uncommon in sandy open pine barrens and fields.

Arabis lyrata L. SAND CRESS.
Found most frequently on Grand Sable Dunes and on sandstone cliff faces and summits.

Barbarea vulgaris R.Br. YELLOW ROCKET.
Disturbed areas in open ground. Collected only at Miners Castle.

Berteroa incana (L.) DC. HOARY ALYSSUM.
Common in disturbed habitats such as roadsides, and in sandy habitats.

Dentaria diphylla Michx. CRINKLEROOT.
A common spring flowering species of rich deciduous woodland.

Dentaria laciniata Muhl. TOOTHWORT.
A species of rich mesic woodland, much less common than *D. diphylla.*

Lepidium densiflorum Schrad. SMALL PEPPERGRASS.
A weed of roadsides and open sandy areas.

Nasturtium officinale R.Br. WATER CRESS.
An uncommon weed in cold flowing and still water.

Rorippa islandica (Oeder) Borbas var. fernaldiana Butters & Abbe. MARSH CRESS.
Uncommon in marshes.

CUPRESSACEAE (CYPRESS FAMILY)

Juniperus communis L. var. depressa Pursh. COMMON JUNIPER.
Occasional to common on sand dunes and beach ridges.

Thuja occidentalis L. ARBOR VITAE, WHITE-CEDAR.
A very common dominant tree of lowlands.

CYPERACEAE (SEDGE FAMILY)

Carex arctata Boott.
Found in rich deciduous woodland to moist cedar swamps.

Carex bebbii (Bailey) Fern.
Found on moist sandy beaches of inland lakes.

Carex brunnescens (Pers.) Poiret.
Collected in a second-growth beech-maple woods. Also to be found in coniferous swamps.

Carex canescens L.
Collected in second-growth cedar swamp and in alder thicket.

Carex cephalantha (Bailey) Bickn.
Collected in open marsh.

Carex chordorrhiza L. f.
Collected once in an open cedar swamp on Au Sable Point.

Carex communis Bailey.
A sedge of upland woods, collected in sandy pineland, under balsam fir, and along logging road in deciduous woods.

Carex crawfordii Fern.
In such locations as birch-maple forest near Miners Castle, common by side of road through beech-maple woods, vicinity of Au Sable Pt. and along logging road through deciduous woods.

Carex cristatella Britt.
Munising Falls. Wet birch-maple woods.

Carex deflexa Hornem.
Collected on an upland ridge near cedar swamp on Au Sable Pt.

Carex deweyana Schw.
Several collections in the vicinity of Miners Falls and Miners Castle in birch-maple woods.

Carex diandra Schrank.
Collected at edge of sphagnum bog.

Carex disperma Dewey.
An abundant sedge in shaded wet areas, as in conifer swamps.

Carex eburnea Boott.
Local; sandy soil in alluvial thicket near mouth of Sable Creek and in dry jack pine flats in Grand Sable Dunes.

Carex flava L.
Fairly common on wet sandy shores of inland lakes and streams.

Carex garberi Fern.
Collected in rock crevices along Lake Superior in vicinity of Au Sable Pt.

Carex gynandra Schw.
A common sedge in wet woods and openings, especially along old logging roads.

Carex gynocrates Drejer.
Occasional in sphagnum cedar swamp on Au Sable Pt.

Carex houghtoniana Dewey.
Border of rich woods.

Carex intumescens Rudge.
Fairly common in wet woods, depressions in rich woods and in swamps.

Carex lasiocarpa Ehrh.
A common sedge in aquatic habitats such as open bogs.

Carex lenticularis Michx.
Collected on exposed sandstone rocks of Lake Superior and in 3-6 inches of water in Grand Sable Lake.

Carex leptalea Wahl.
A common species of shaded wet areas, as in cedar swamps.

Carex leptonervia Fern.
Found in rich deciduous woods and also in cedar swamps.

Carex limosa L.
Collected in sphagnum bog.

Carex oligosperma Michx.
Common mat-forming sedge in bogs.

Carex pauciflora Lightf.
Infrequent to occasional sedge of cedar swamps.

Carex paupercula Michx.
Found in sphagnum bog mats.

Carex peckii Howe.
Found in mixed conifer-deciduous woods, especially hemlock-beech-maple.

Carex pedunculata Willd.
Found in beech-sugar maple woods.

Carex pensylvanica Lam.
A common sedge of sandy barrens and woods.

Carex plantaginea Lam.
Found in rich deciduous woods in vicinity of Miners Falls.

Carex pseudo-cyperus L.
Collected at edge of small lake (Arsenault) under alders.

Carex projecta Mack.
Found in more or less disturbed places in shade, such as in the stream below Sable Falls and along trail near Miners Falls.

Carex retrorsa Schw.
Not an uncommon sedge on lake and stream borders, and in damp shaded ground of disturbed woods.

Carex rostrata Stokes.
In a variety of wet habitats, most commonly on shorelines of lakes and streams, and in bogs.

Carex rugosperma Mack.
Collected in second-growth pine stand in vicinity of Grand Sable Dunes.

Carex scabrata Schw.
A sedge of wet springy places and streamsides.

Carex scoparia Willd.
Munising Falls. Edge of cold streamlet in birch-maple forest.

Carex sterilis Willd.
Found in sphagnum bog mats and sandy flats of lakes.

Carex stipata Willd.
Rich deciduous woods above Miners Falls.

Carex stricta Lam.
Found in wet places usually in standing water, as in marshes.

Carex trisperma Dewey.
A common species of conifer swamps.

Carex umbellata Willd.
Collected on an open stabilized sand dune in the Grand Sable Dunes.

Carex vaginata Tausch.
A boreal species found in cedar swamp about one mile east of Twelve Mile Beach Campground (T49N R15W sec. 16).

Carex vesicaria L.
A common sedge in wet places, such as along streamsides, on lakeshores and in marshes. Much of the material collected looks intermediate to *Carex rostrata.*

Cladium mariscoides (Muhl.) Torr. TWIG-RUSH.
An occasional to common species of shores and especially bogs.

Dulichium arundinaceum (L.) Britton. POND SEDGE, THREE-WAY SEDGE.
A common emergent aquatic of shallow lakes and bogs.

Eleocharis elliptica Kunth.
Found in damp sand on lakeshores.

Eleocharis intermedia (Muhl.) Schultes. MATTED SPIKE-RUSH.
Collected in bog mat of Miners Lake. Local.

Eleocharis obtusa (Willd.) Schultes. BLUNT SPIKE-RUSH.
Occasional to common on lake shores in sand or mud.

Eleocharis smallii Britt.
An abundant species in shallow water of most lakes.

Eriophorum angustifolium Honck. NARROW-LEAVED COTTON-GRASS.
In a variety of wet to damp habitats.

Eriophorum gracile W. D. J. Koch. SLENDER COTTON-GRASS.
Found in open marshes and in bog mats.

Eriophorum spissum Fern.
Found mainly in open bogs but also in thinly wooded conifer swamps.

Eriophorum tenellum Nutt. COTTON-GRASS.
Occasional in bogs and conifer swamps.

Eriophorum viridi-carinatum (Engelm.) Fern.
Collected in 1916 by C. K. Dodge in a swamp near Munising.

Rhynchospora alba (L.) Vahl. WHITE BEAK-RUSH.
Abundant in bog mats and on lake edges.

Rhynchospora fusca (L.) Ait. f. SOOTY BEAK-RUSH.
Locally common in beach pools, north side of Big Beaver Lake; also in bog mats.

Scirpus acutus Bigelow. HARDSTEM BULRUSH.
A common species of shallow water of lakes.

Scirpus americanus Pers. CHAIRMAKER'S RUSH.
A common species in shallow water of sand-bottom lakes.

Scirpus atrovirens Willd. DARK GREEN RUSH.
Found in wet places, from lake marshes to openings of old logging roads.

Scirpus cespitosus L. var. callosus Bigelow.
Collected on the boggy shore of Kingston Lake by J. A. Churchill in 1964.

Scirpus cyperinus (L.) Kunth. WOOL-GRASS.
Common in bogs, swamps, along trails in wet places, and in roadside ditches.

Scirpus microcarpus Presl. var. rubrotinctus (Fern.) M. E. Jones. [=S. rubrotinctus Fern.].
Common in a variety of wet to damp open habitats.

Scirpus validus Vahl var. creber Fern. GREAT BULRUSH, SOFTSTEM BULRUSH.
Common in shallow water of lakes and in marshes.

DROSERACEAE (SUNDEW FAMILY)

Drosera intermedia Hayne. NARROW-LEAVED SUNDEW.
Found in sphagnum bogs, in wet sand, and on fallen logs near lakes.

Drosera rotundifolia L. ROUND-LEAVED SUNDEW.
A species of bogs and other habitats similar to those of the preceding species.

EMPETRACEAE (CROWBERRY FAMILY)

Empetrum nigrum L. BLACK CROWBERRY.
Known for many years in the Pictured Rocks area only from Miners Castle, this arctic species was also found to grow on the protected winter beach of Twelve Mile Beach.

EQUISETACEAE (HORSETAIL FAMILY)

Equisetum arvense L. HORSETAIL.
Common on sand beaches and dunes.

*Equisetum fluviatile L. PIPES.
Growing in small ponds and around lake margins.

Equisetum hyemale L. var. intermedium A.A. Eat. [=E. laevigatum]. SMOOTH SCOURING-RUSH.
Collected in damp to dry sandy ridges of Sand Pt.

Equisetum pratense Ehrh.
Occasional in wet to wet-mesic deciduous to conifer woods.

Equisetum scirpoides Michx. DWARF SCOURING-RUSH.
Common on steep seepy shaded areas, such as ravine slopes.

*Equisetum sylvaticum L. WOOD HORSETAIL.
Found in wet to wet-mesic woods.

ERICACEAE (HEATH FAMILY)

*Andromeda glaucophylla Link. BOG ROSEMARY.
Occasional to abundant in bog areas such as on Sand Point and northeast of Big Beaver Lake.

Arctostaphylos uva-ursi (L.) Spreng. BEARBERRY.
Occasional to common in sandy open areas, usually under conifers.

Chamaedaphne calyculata (L.) Moench. LEATHERLEAF.
A common species in bogs and marshes, sometimes forming almost pure stands.

Chiogenes hispidula (see Gaultheria hispidula).

Epigaea repens L. TRAILING ARBUTUS.
Common in mixed to conifer sandy woodland, especially near the Lake Superior shore.

*Gaultheria hispidula (L.) Muhl. CREEPING SNOWBERRY.
Often growing on old logs in cedar swamps, this species also persists on the stabilized winter beaches of Lake Superior.

*Gaultheria procumbens L. WINTERGREEN.
A common species under conifers, especially in sandy soil.

Gaylussacia baccata (Wang.) K. Koch. HUCKLEBERRY.
A common species of pinelands in dry sandy soil.

Kalmia polifolia Wang. BOG LAUREL.
Common in bogs and in wet beach depressions.

Ledum groenlandicum Oeder. LABORADOR-TEA.
Found commonly in bogs, on the sandy winter beach of Lake Superior, as well as in rock crevices along the coast.

Vaccinium angustifolium Ait. [sens. lat.] LOW BLUEBERRY.
A common species of sandy woodland and barrens.

Vaccinium macrocarpon Ait. LARGE CRANBERRY.
Found in bog mats as well as in damp beach depressions and on beach flats.

Vaccinium membranaceum Dougl. BILBERRY.
An occasional to abundant species in thin woods, both mixed and conifer.

Vaccinium myrtilloides Michx. CANADA BLUEBERRY.
A common species of sandy barrens and pineland.

*Vaccinium ovalifolium Sm.
An occasional to common species of upland conifer woodland and on rock ledges.

Vaccinium oxycoccos L. SMALL CRANBERRY.
Found in sphagnum bog mats.

Vaccinium vacillans Torr. LATE LOW BLUEBERRY.
Sandy woods near Chapel Rock.

ERIOCAULACEAE (PIPEWORT FAMILY)

Eriocaulon septangulare With. PIPEWORT.
Occasional in sphagnum bog mats and on fallen logs in lakes and ponds.

FABACEAE (see Leguminosae)

FAGACEAE (BEECH FAMILY)

Fagus grandifolia Ehrh. BEECH.
An abundant tree which is codominant with sugar maple in mesic woods.

Quercus rubra L. RED OAK.
Occasional tree in pineland but also on stabilized dune edges.

FUMARIACEAE (FUMITORY FAMILY)

Dicentra canadensis (Goldie) Walp. SQUIRREL-CORN.
A spring ephemeral of rich mesic woods.

Dicentra cucullaria (L.) Bernh. DUTCHMAN'S BREECHES.
A spring ephemeral of rich woods.

GENTIANACEAE (GENTIAN FAMILY)

*Menyanthes trifoliata L. var. minor Raf. BUCKBEAN.
A characteristic species of bog mats and bog mat edges.

Gentiana rubricaulis Schwein. CLOSED GENTIAN.
Found in damp thickets and on open damp sand flats of lakes.

GERANIACEAE (GERANIUM FAMILY)

Geranium robertianum L. HERB ROBERT.
Occasional to common in deciduous woodland, especially along trails in the Chapel Lake area.

GRAMINEAE (GRASS FAMILY)

Agropyron trachycaulum (Link) Malte. SLENDER WHEAT GRASS.
Found most frequently in sandy dune areas, such as Grand Sable Dunes, Twelve Mile Beach and Sand Point.

Agrostis gigantea Roth. REDTOP GRASS.
Found especially in open disturbed areas, where it is frequent.

Agrostis hyemalis (Walter) BSP. [incl. A. scabra] TICKLE GRASS.
Found in such habitats as stabilized dune slopes, Grand Sable Dunes and in crevices in wet sandstone cliffs.

Agrostis perennans (Walter) Tuckerman. THIN GRASS.
Loose soil on top of and on seepy north-facing sandstone cliffs, near Chapel Rock.

Alopecurus aequalis Sobol. SHORT-AWNED FOXTAIL.
Alder swamp, west end of Little Chapel Lake.

Ammophila breviligulata Fern. MARRAM GRASS, BEACH GRASS.
The common large grass found on the Lake Superior shoreline beaches and on Grand Sable Dunes.

Andropogon scoparius Michx. LITTLE BLUESTEM GRASS.
Common on Grand Sable Dunes.

Brachyeletrum erectum (Roth) Beauv. var. septentrionale Babel. LONG-AWNED WOOD GRASS.
Occasional in deciduous woodland.

Bromus ciliatus L. FRINGED BROME GRASS.
Near Grand Marais. In small clearing on high bank of Lake Superior. (C. K. Dodge collection in 1916.)

Bromus inermis Leysser. HUNGARIAN BROME GRASS.
Fairly common to abundant on roadsides.

*Calamagrostis canadensis (Michx.) Nutt. BLUE-JOINT GRASS.
In wet, marshy areas and on lakeshores, such as on Sand Point and small lakes east of Twelve Mile Beach Campground.

Calamagrostis inexpansa Gray. REED GRASS.
Locally abundant on Grand Sable Dunes.

Cinna latifolia (Goepp.) Griseb. BROAD-LEAVED WOOD REED GRASS.
Wooded sandstone slopes; abundant in deciduous woods, along trails, etc.

Dactylis glomerata L. ORCHARD GRASS.
An abundant weed in former agricultural and residential areas.

Danthonia spicata (L.) R. & S. POVERTY OAT GRASS.
Found in open sandy pine barrens.

Deschampsia cespitosa (L.) Beauv. TUFTED HAIR GRASS.
Collected on rocks near Miners Castle.

Deschampsia flexuosa (L.) Beauv. COMMON HAIR GRASS.
A common species of open to shaded sand, especially near beaches and on top of the Pictured Rocks.

Elymus canadensis L. CANADA WILD RYE.
Occasional on sand beaches and dunes of Lake Superior.

Elymus glaucus Buckley.
Sandy thickets and dunes of Grand Sable.

Elymus mollis Trin. DUNE GRASS.
An interesting boreal grass occurring occasionally to abundantly on Grand Sable Dunes to Chapel Beach, but not as far west as Miners Beach and Sand Point. This species has much of its Michigan range within the park.

Festuca occidentalis Hooker. WESTERN FESCUE GRASS.
One of a number of western U.S. disjuncts occurring in the Upper Great Lakes region. Locally abundant in mixed-deciduous woods and thickets.

Festuca saximontana Rydb.
An abundant grass on stabilized dunes and open ridges of Grand Sable Dunes.

Glyceria borealis (Nash) Batch. NORTHERN MANNA GRASS.
Common on stream and lake borders and in other wet habitats.

Glyceria canadensis (Michx.) Trin. RATTLESNAKE GRASS.
Like the previous species in its habitat preferences.

Glyceria grandis S. Watson. REED MANA GRASS.
Collected and seen only once in shallow water of Grand Sable Lake.

Glyceria striata (Lam.) Hitchc. FOWL MANNA GRASS.
A common grass in a variety of wet habitats, from trail sides to marshes to alder thickets.

Hystrix patula Moench. BOTTLEBRUSH GRASS.
An occasional grass in deciduous woods, especially on borders.

*Leersia oryzoides (L.) Sw. RICE CUT GRASS.
Seen only in wetland adjacent to Arsenault Lake west of Little Beaver Lake.

Melica smithii (Porter) Vasey.
Occasional to locally common in rich deciduous woods. Another western U.S. species occurring disjunctly in the upper Great Lakes region.

Milium effusum L. WOOD MILLET GRASS.
Frequent in rich deciduous to mixed woods.

Oryzopsis asperifolia Michx. ROUGH-LEAVED RICE GRASS.
Occasional in dry to mesic woods.

Panicum columbianum Scribner. HEMLOCK PANIC GRASS.
In dry sandy habitats.

Panicum depauperatum Muhl. STARVED PANIC GRASS.
A species of dry sandy woods and barrens.

Panicum implicatum Britton. [=P. lanuginosum var. implicatum of Gray's Manual]. HAIRY PANIC GRASS.
Probably the most common of the panic grasses, in dry sandy soil.

Phalaris arundinacea L. REED CANARY GRASS.
Not widespread but common where found on shore margins and in marshes.

Phleum pratense L. TIMOTHY.
Common on roadsides and in old agricultural land.

Poa alsodes Gray. GROVE BLUEGRASS.
A grass of mainly rich deciduous woods.

Poa annua L. ANNUAL BLUEGRASS.
A common weed in former lawns and disturbed places.

Poa compressa L. CANADA BLUEGRASS.
A common weedy species.

Poa nemoralis L.
Collected in dry woods near Lake Superior.

Poa palustris L. MARSH BLUEGRASS.
An occasional grass of marshes and open swamps.

Poa pratensis L. KENTUCKY BLUEGRASS.
A weed in disturbed places.

Schizachne purpurascens (Torrey) Swallen. FALSE MELIC GRASS.
A grass of rich deciduous to mixed woods.

Sphenopholis intermedia Rydb. SLENDER WEDGE GRASS.
Near Chapel Rock. Uncommon in loose soil on top and on seepy north-facing sandstone cliffs by Lake Superior.

Trisetum spicatum (L.) Richter.
In more or less open sandy soil near the coast.

GUTTIFERAE (see Hypericaceae)

HALORAGACEAE (WATER-MILFOIL FAMILY)

Myriophyllum alterniflorum DC.
Locally abundant in shallow water of Big Beaver Lake.

Myriophyllum exalbescens Fern.
Common in lakes.

Myriophyllum heterophyllum Michx.
An uncommon species in Chapel Lake.

Myriophyllum tenellum Bigel.
Common in shallow water of Big Beaver Lake.

HIPPURIDACEAE (MARE'S-TAIL FAMILY)

Hippuris vulgaris L. MARE'S TAIL.
Seen and collected only on the margin of Miners Lake.

HYDROCHARITACEAE (FROG'S-BIT FAMILY)

Elodea canadensis Michaux. COMMON WATERWEED.
Common floating or attached aquatic in most lakes.

Vallisneria americana Michaux. EEL GRASS, WILD-CELERY.
An occasional species in shallow to deep water of most lakes in the park.

HYPERICACEAE (ST. JOHN'S WORT FAMILY)

Hypericum boreale (Britt.) Bickn. NORTHERN ST. JOHN'S WORT.
Growing in sandy beach pools on north side of Big Beaver Lake. Undoubtedly in other semi-aquatic habitats throughout park.

Hypericum canadense L. CANADIAN ST. JOHN'S WORT.
Found in open sphagnum bog mats and other wet habitats.

Hypericum ellipticum Hook. ST. JOHN'S WORT.
Found on sandy beach flats and other wet habitats.

Hypericum perforatum L. COMMON ST. JOHN'S WORT.
An abundant weed of fields and roadsides.

Hypericum virginicum L. var. fraseri (Spach) Fern. [=Triadenum fraseri]. MARSH ST. JOHN'S WORT.
Found in bogs and marshes.

IRIDACEAE (IRIS FAMILY)

Iris versicolor L. BLUE FLAG.
Common in marshes, lake and stream borders, and other wet habitats.

ISOËTACEAE (QUILLWORT FAMILY)

Isoëtes muricata Dur. QUILLWORT.
Locally common in lakes such as Big Beaver and Grand Sable.

JUNCACEAE (RUSH FAMILY)

Juncus articulatus L.
A common species in wet sandy habitats, from trail edges to stream and lake borders.

Juncus balticus Willd. var. littoralis Engelm. LAKE SHORE RUSH.
A species of wet to damp sand habitats, especially on beach flats.

Juncus brevicaudatus (Engelm.) Fern.
Found on the moist, sandy borders of lakes and streams as well as in sandstone crevices along Lake Superior.

Juncus effusus L. COMMON RUSH.
Munising Falls. Sandy border of cold streamlet, edge of birch-maple forest; also in marshes and on lake and stream borders.

Juncus greenei Oakes & Tuckerman.
Found along shores and along sandy trails.

Juncus pelocarpus Mey. BROWN-FRUITED RUSH.
Beach pools, and sand and gravelly beaches of inland lakes, such as Grand Sable Lake and Big Beaver Lake.

Juncus nodosus L. JOINT RUSH.
Wet open places near Grand Marais. (C. K. Dodge collection in 1916.)

Juncus tenuis Willd. ROADSIDE RUSH.
Common in wet to dry disturbed places such as campgrounds and trails.

JUNCAGINACEAE (ARROW-GRASS FAMILY)

Scheuchzeria palustris L. ARROW-GRASS.
Uncommon in sphagnum bogs.

LABIATAE (MINT FAMILY)

Galiopsis tetrahit L. COMMON HEMP-NETTLE.
Occasional to common in more or less disturbed places, as along old logging roads.

Lamium purpureum L. PURPLE DEAD-NETTLE.
Collected only on Sand Point near old cottages. Growing in sandy soil under alders.

*Leonurus cardiaca L. MOTHERWORT.
Seen only on forest edge near concession stand at Miners Castle.

Lycopus uniflorus Michx. NORTHERN BUGLE WEED.
Common in all types of damp to aquatic habitats.

Mentha arvensis L. WILD MINT.
An occasional species of open marshy areas.

Monarda fistulosa L. WILD BERGAMOT.
An occasional species of fields and roadsides.

Prunella vulgaris L. var. lanceolata (Bart.) Fern. SELFHEAL.
A common species in woodland habitats, especially in disturbance areas.

Satureja vulgaris (L.) Fritsch var. neogaea Fern. DOGMINT.
Occasional to common in damp to dry woodlands, often along trails.

Scutellaria epilobiifolia A. Hamilton. MARSH SKULLCAP.
Common in marshes.

Scutellaria lateriflora L. MAD-DOG SKULLCAP.
Common in marshes and in other wet places.

LAMIACEAE (see Labiatae)

LEGUMINOSAE (PEA FAMILY)

Lathyrus japonicus Willd. var. glaber (Ser.) Fern. BEACH PEA.
A common species on dunes and the beach strand on Lake Superior.

Lathyrus sylvestris L. PERENNIAL PEA.
An uncommon weed growing along the roadside near the entrance to Munising Falls.

Medicago lupulina L. BLACK MEDICK.
Common on roadsides and in disturbed areas.

Medicago sativa L. ALFALFA.
A common weed in former agricultural fields and on roadsides.

Melilotus alba Desr. WHITE SWEET-CLOVER.
A common roadside and field weed.

Melilotus officinalis (L.) Lam. YELLOW SWEET-CLOVER.
A common roadside and field weed.

Trifolium pratense L. RED CLOVER.
A weed especially prevalent on the Grand Sable Dunes; also on roadsides.

Trifolium repens L. WHITE CLOVER.
Found in disturbed places near human inhabitation and on Grand Sable Dunes.

LEMNACEAE (DUCKWEED FAMILY)

Lemna minor L. SMALL DUCKWEED.
Common in quiet waters of most lakes and in marshes.

Lemna trisulca L. FORKED DUCKWEED.
Uncommon to common in quiet water of lakes and marshes.

Spirodela polyrhiza (L.) Schleiden. GREAT DUCKWEED.
Seen and collected only in Arsenault Lake in shallow water.

LENTIBULARIACEAE (BLADDERWORT FAMILY)

Pinguicula vulgaris L. BUTTERWORT.
Restricted to dripping semi-shaded to shaded cliffs on the Pictured Rocks, in which habitat it is common.

Utricularia cornuta Michx. HORNED BLADDERWORT.
Growing in sandy beach pools on north side of Big Beaver Lake and in bog mats.

Utricularia intermedia Hayne. FLAT–LEAVED BLADDERWORT.
A species most frequently encountered in small pools in sphagnum bog mats.

*Utricularia vulgaris L. COMMON BLADDERWORT.
A common species of stagnant backwaters of lakes.

LILIACEAE (LILY FAMILY)

Allium tricoccum Aiton. WILD LEEK.
In rich moist deciduous woods throughout park.

Clintonia borealis (Aiton) Raf. BLUEBEAD.
A common species of many habitats, most abundant in conifers of lowland and near Lake Superior, less abundant in rich deciduous woods.

Erythronium americanum Ker. YELLOW TROUT-LILY.
Abundant in deciduous woods.

Hepatica acutiloba DC. SHARP-LOBED HEPATICA.
Occasional in deciduous woods.

Hepatica americana (DC.) Ker. ROUND-LOBED HEPATICA.
Like the previous species found in deciduous woods.

*Maianthemum canadense Desf. CANADA MAYFLOWER.
An abundant species in all types of terrestrial habitats.

Medeola virginiana L. INDIAN CUCUMBER-ROOT.
Uncommon in beech-maple woods.

Polygonatum pubescens (Willd.) Pursh. DOWNY SOLOMON'S SEAL.
A common species in deciduous rich woods.

Smilacina racemosa (L.) Desf. FEATHERY FALSE SOLOMON'S SEAL.
An occasional species of woods and wood edge habitats.

Smilacina stellata (L.) Desf. STARRY FALSE SOLOMON'S SEAL.
Occasional on Grand Sable Dunes.

Smilacina trifolia (L.) Desf. THREE-LEAVED FALSE SOLOMON'S SEAL.
Occasional in cedar swamps.

Streptopus amplexifolius (L.) DC. TWISTED-STALK.
Occasional in rich seepy shaded areas.

Streptopus roseus Michx. var. longipes (Fern.) Fassett. TWISTED-STALK.
More common than the previous in wet to mesic woods.

Trillium cernuum L. NODDING TRILLIUM.
Occasional to common in deciduous woods.

Trillium grandiflorum (Michx.) Salisb. LARGE-FLOWERED TRILLIUM.
A very common species of rich deciduous woods.

LYCOPODIACEAE (CLUB-MOSS FAMILY)

Lycopodium annotinum L. INTERRUPTED CLUB-MOSS.
Common especially near the coast in conifer woodland.

Lycopodium clavatum L. RUNNING GROUND-PINE.
Common in similar habitats to those of *L. annotinum.*

Lycopodium complanatum L. TRAILING GROUND-PINE.
Occasional in various upland woods.

Lycopodium inundatum L. BOG CLUB-MOSS.
Common on wet sandy beach flats of inland lakes such as Big Beaver Lake.

Lycopodium lucidulum Michx. SHINING CLUB-MOSS.
A common and characteristic species of mesic beech-maple forests.

Lycopodium obscurum L. GROUND-PINE.
Common in various woodland types.

MALVACEAE (MALLOW FAMILY)

Malva rotundifolia L. ROUND-LEAVED MALLOW.
A rare weed in this area, collected in waste ground at Twelve Mile Beach Campground.

MYRICACEAE (MYRTLE FAMILY)

Comptonia peregrina (L.) Coult. SWEET-FERN.
Collected only from Kingston Lake area by E. G. Voss in sandy pine woods.

Myrica gale L. SWEET GALE.
A common species in damp to wet habitats; also in depressions at base of winter beaches of Lake Superior.

NAJADACEAE (NAIAD FAMILY)

Najas flexilis (Willd.) Rostk. & Schmidt. SLENDER NAIAD.
Occasional to abundant in lakes.

NYMPHAEACEAE (WATER-LILY FAMILY)

Nuphar variegatum Engelm. [=N. luteum (L.) Sibth. & Sm. subsp. variegatum (Engelm.) Beal]. YELLOW POND-LILY.
A common species in shallow water of most lakes.

Nymphaea odorata Ait. WHITE WATER-LILY.
A common species of most lakes.

OLEACEAE (OLIVE FAMILY)

Fraxinus nigra Marsh. BLACK ASH.
Occasional to abundant tree in swamps and along streams and lakes.

Fraxinus pennsylvanica Marsh. var. subintegerrima (Vahl) Fern. GREEN ASH.
An occasional tree of low stream banks and in low woods.

ONAGRACEAE (EVENING-PRIMROSE FAMILY)

Circaea alpina L. SMALL ENCHANTER'S NIGHTSHADE.
A common species in wet shaded habitats such as wet deciduous woods and conifer swamps.

*Epilobium angustifolium L. FIREWEED.
An abundant plant in openings and thickets throughout the park.

Epilobium glandulosum Lehm. var. adenocaulon (Haussk.) Fern. NORTHERN WILLOW-HERB.
Occurring on damp sandy cliffs, in openings and wetland.

Epilobium leptophyllum Raf. BOG WILLOW-HERB.
A species of open to semi-shaded bogs, marshes and cedar swamps.

Ludwigia palustris (L.) Ell. MARSH PURSLANE.
Growing in shallow water under *Thuja,* near campground on Little Beaver Lake.

Oenothera biennis L. COMMON EVENING-PRIMROSE.
Common in dunes, on beaches, in pine barrens, and fields.

Oenothera parviflora L. EVENING-PRIMROSE.
Frequent on sand dunes north of Grand Sable Lake.

OPHIOGLOSSACEAE (GRAPE-FERN FAMILY)

Botrychium lunaria (L.) Sw. MOONWORT.
Under jack pines in sand behind Grand Sable Dunes.

Botrychium matricariaefolium A.Br. GRAPE-FERN.
Common in jack pine stands in the vicinity of Grand Sable Dunes.

Botrychium minganense Vict. GRAPE-FERN.
Collected in the vicinity of Grand Sable Dunes.

Botrychium multifidum (Gmel.) Rupr. LEATHERY GRAPE-FERN.
Mossy woods, SW side of Little Beaver Lake.

Botrychium simplex E. Hitchc. GRAPE-FERN.
Known from jack pine areas and deciduous woodland near Grand Sable Dunes and Sable Falls.

Botrychium virginianum (L.) Sw. RATTLESNAKE FERN.
Found in deciduous to mixed woods throughout park; fairly common.

ORCHIDACEAE (ORCHID FAMILY)

Calopogon tuberosus (L.) BSP. [=C. pulchellus of Gray's Manual]. GRASS-PINK.
Occasional in sphagnum bogs.

Calypso bulbosa (L.) Oakes. CALYPSO.
Restricted to areas near Grand Sable Dunes.

Corallorhiza maculata Raf. SPOTTED CORAL-ROOT.
Most often found in mesic woodland, less often in conifer woodland.

Corallorhiza striata Lindl. STRIPED CORAL-ROOT.
A beautiful species found in rich mixed woodland, not uncommon.

Corallorhiza trifida Chat. EARLY CORAL-ROOT.
Relatively common in all types of wooded habitats, from rich mesic woods to dry pineland.

Cypripedium acaule Aiton. STEMLESS LADY'S SLIPPER.
A common to abundant orchid in semi-open sandy soil.

Cypripedium arietinum R.Br. RAM'S HEAD LADY'S SLIPPER.
All observations of this orchid have been in semi-shaded dunes in the vicinity of Grand Sable Lake.

*Cypripedium calceolus L. YELLOW LADY'S SLIPPER.
Not seen by the author, but included because of several independent sight reports by NPS rangers. It is said to occur on shaded dune slopes in the Grand Sable Dune area.

Goodyera oblongifolia Raf. GIANT RATTLESNAKE-PLANTAIN.
Throughout the park in mixed to conifer upland woods and thickets.

Goodyera pubescens (Willd.) R.Br. DOWNY RATTLESNAKE-PLANTAIN.
Seen and collected only once in a dry white cedar thicket on Sand Point.

Goodyera repens (L.) R.Br. var. ophioides Fern. DWARF RATTLESNAKE-PLANTAIN.
Found throughout the park under conifers, but preferring hemlock.

Goodyera tesselata Lodd.
An orchid of dry sand, usually under pines, throughout the park.

Habenaria clavellata (Michx.) Spreng. CLUB-SPUR ORCHID.
Occasional in sphagnum bog mats.

Habenaria dilatata-hyperborea complex.
Intermediates between *Habenaria dilatata* and *Habenaria hyperborea* are found in the vicinity of Sable Falls and Grand Sable Lake.

Habenaria hookeri Gray. HOOKER'S ORCHID.
Occasional in mixed woods in a sandy substrate such as behind old dunes.

Habenaria hyperborea (L.) R.Br. TALL NORTHERN BOG ORCHID.
Occasional in cedar swamps, along stream and lake borders, and in roadside ditches.

Habenaria obtusata (Pursh) Richardson. BLUNT-LEAF ORCHID.
A very common orchid in cedar swamps and wet mixed woods.

Habenaria orbiculata (Pursh) Torrey. ROUND-LEAVED ORCHID.
In sandy mixed woods in the vicinity of Grand Sable Lake and Sable Falls.

Habenaria psycodes (L.) Spreng. PURPLE FRINGED ORCHID.
Occasional in wet mixed or coniferous woods. Often becoming common in roadside ditches in northern Michigan and Wisconsin but not so noted in the park.

Habenaria viridis (L.) R.Br. var. bracteata (Willd.) Gray. BRACTED ORCHID.
Occasional in sandy wet and mesic woods.

Listera convallarioides (Sw.) Nutt. BROAD-LIPPED TWAYBLADE.
A common orchid in wet boggy woods to wet mesic woods. The related *Listera auriculata* has been collected just east of Grand Marais and most likely occurs in the park.

Listera cordata (L.) R.Br. HEARTLEAF TWAYBLADE.
A locally abundant orchid in wet boggy woods and in sandy jack pine flats near Lake Superior.

Listera ×veltmanii Case.
The type locality for this presumed hybrid between *Listera auriculata* and *L. convallarioides* is near Sable Falls. See comments under *Listera convallarioides.*

Malaxis monophylla (L.) Sw. var. brachypoda (Gray) Morris. [=M. brachypoda (Gray) Fern.] WHITE ADDER'S-MOUTH.
Found in the vicinity of Grand Sable Dunes, in jack pine hollows and moist mixed woodland.

Pogonia ophioglossoides (L.) Ker. ROSE POGONIA.
An occasional orchid in sphagnum bogs.

Spiranthes cernua (L.) Richard. NODDING LADIES' TRESSES.
Occasional in damp sandy habitats.

Spiranthes lacera (Raf.) Raf. SLENDER LADIES' TRESSES.
Occasional to common in dry sandy pine barrens.

OROBANCHACEAE (BROOM-RAPE FAMILY)

Epifagus virginiana (L.) Bart. BEECH-DROPS.
Associating as a parasite of beech throughout the park.

OSMUNDACEAE (FLOWERING-FERN FAMILY)

*Osmunda cinnamomea L. CINNAMON FERN.
An occasional to common species in wet boggy to mesic woods.

Osmunda claytoniana L. INTERRUPTED FERN.
An occasional to common species in similar habitats to the previous species.

Osmunda regalis L. var. spectabilis (Willd.) Gray. ROYAL FERN.
Found in a variety of damp to wet habitats, from alder thickets to semi-open marshland.

OXALIDACEAE (WOOD-SORREL FAMILY)

Oxalis europaea Jord. TALL WOOD-SORREL.
An uncommon weed of disturbed places.

Oxalis montana Raf. COMMON WOOD-SORREL.
Common in wet boggy mixed woods.

PAPAVERACEAE (POPPY FAMILY)

Dicentra–see under FUMARIACEAE.

Sanguinaria canadensis L. BLOODROOT.
An uncommon species of rich deciduous woods.

PINACEAE (PINE FAMILY)

Abies balsamea (L.) Miller. BALSAM FIR.
An abundant tree throughout the park in a variety of habitats. If often forms dense impenetrable stands in logged areas.

Juniperus–see under CUPRESSACEAE.

*Larix laricina (DuRoi) K. Koch. TAMARACK.
A very common tree in wet habitats.

Picea glauca (Moench) A. Voss. WHITE SPRUCE.
An abundant tree found in all types of habitats but most commonly on uplands.

Picea mariana (Miller) BSP. BLACK SPRUCE.
Most common in bogs, wet places and on winter beaches of Lake Superior.

Pinus banksiana Lamb. JACK PINE.
A common species in dry sandy areas, being dominant in groves on the Grand Sable Dunes in which rich assemblages of plants grow.

Pinus resinosa Aiton. RED PINE.
A codominant species in dry sandy habitats. Most of the large trees of this coveted lumber species have been removed from the park and the remaining stands mainly represent second generation growth.

*Pinus strobus L. WHITE PINE.
Often codominant with red pine in dry sandy soil and just as important a lumber tree as the previous species.

Thuja—see under CUPRESSACEAE.

Tsuga canadensis (L.) Carr. HEMLOCK.
A common tree in well-drained sites, often forming impressive stands where spared from lumbering.

PLANTAGINACEAE (PLANTAIN FAMILY)

Plantago lanceolata L. ENGLISH PLANTAIN.
An occasional weed in disturbed places.

Plantago major L. COMMON PLANTAIN.
Found in disturbed places throughout park.

Plantago rugelii Dcne. RED-STALKED PLANTAIN.
An occasional species of highly disturbed places.

POACEAE (see Gramineae)

POLYGALACEAE (MILKWORT FAMILY)

*Polygala paucifolia Willd. GAYWINGS, FRINGED POLYGALA.
A species of from dry to wet-mesic woods, but usually in mixed woods.

POLYGONACEAE (KNOTWEED FAMILY)

Polygonella articulata Michx. JOINTWEED.
A species of unstable sand.

Polygonum amphibium L. var. stipulaceum Coleman. WATER KNOTWEED.
A floating-leaved aquatic plant of quiet water.

Polygonum achoreum Blake. LEATHERY KNOTWEED.
Occasional in sandy roadways.

Polygonum aviculare L. COMMON KNOTWEED.
A weed of disturbed places, especially common in parking lots.

Polygonum cilinode Michaux. FRINGED KNOTWEED.
Found mainly in open sandy areas and on sandstone cliffs.

Polygonum persicaria L. LADY'S THUMB.
An occasional weed of damp disturbed places.

Polygonum punctatum Ell. SMARTWEED.
A species of wet habitats as along lakes and rivers and in marshes.

Polygonum ramosissimum Michx. BUSHY KNOTWEED.
Abundant (in 1948) in sand along woods road back of bluffs near Log Slide.

Rumex acetosella L. FIELD SORREL.
Locally frequent in disturbed dry to damp soils.

Rumex crispus L. CURLY DOCK.
An occasional weed along roads and in swampy ground.

Rumex obtusifolius L. BITTER DOCK.
A weed of damp roadsides, logging roads and mixed woods, often appearing as if native.

POLYPODIACEAE (FERN FAMILY)

Adiantum pedatum L. MAIDENHAIR FERN.
Rarely encountered, in rich woods.

Athyrium filix-femina (L.) Roth var. angustum (Willd.) Lawson. LADY FERN.
Found in habitats from moist deciduous woodland to open rock crevices.

Cryptogramma stelleri (Gmel.) Prantl. SLENDER ROCK BRAKE.
A locally common fern on shaded escarpment cliffs. This species has a very limited distribution in the rest of the state. (See Dodge, 1918a.)

*Cystopteris bulbifera (L.) Bernh. BULBLET FERN.
As with the next species, found on shaded sandstone cliffs on the Pictured Rocks escarpment.

Cystopteris fragilis (L.) Bernh. FRAGILE FERN.
Common on damp shaded sandstone cliffs.

Dryopteris disjuncta (Ledeb.) C. V. Mort. (See Gymnocarpium dryopteris.)

Dryopteris marginalis (L.) Gray. MARGINAL SHIELD FERN.
Seen and collected only in the Miners Basin in rich woods.

*Dryopteris phegopteris (L.) Christens. LONG BEECH FERN.
A common species of rich deciduous woods to cedar swamps.

Dryopteris spinulosa (O. F. Mull.) Watt. SPINULOSE SHIELD FERN.
A common species of mesic woods.

Gymnocarpium dryopteris (L.) Newm. OAK FERN.
A common fern of wet-mesic woodland and cedar swamps.

*Matteuccia struthiopteris (L.) Todaro var. pensylvanica (Willd.) Morton. [=Pteretis pensylvanica (Willd.) Fern. of Gray's Manual]. OSTRICH FERN.
Occasional to locally common in wet woods and alder thickets.

*Onoclea sensibilis L. SENSITIVE FERN.
Found in a variety of wet marshy to swampy habitats.

Polypodium virginianum L. POLYPODY.
On rock outcrops and large boulders throughout park.

Polystichum braunii (Spenner) Fée var. purshii Fern. BRAUN'S HOLLY FERN.
Known from rich woods near Miners Falls, Little Beaver Lake, Munising Falls, sandstone cliff near Chapel Rock.

Polystichum lonchitis (L.) Roth. HOLLY FERN.
A locally common fern in rich deciduous woods, most prevalent in Miners Basin region.

Pteretis (see Matteuccia).

*Pteridium aquilinum (L.) Kuhn var. latiusculum (Desv.) Underw. BRACKEN FERN.
A ubiquitous fern in sandy pine woods and barrens.

PONTEDERIACEAE (PICKEREL-WEED FAMILY)

Heteranthera dubia (Jacq.) MacM. WATER STAR-GRASS.
Occasional in Little Beaver Lake.

PORTULACACEAE (PURSLANE FAMILY)

Claytonia caroliniana Michx. SPRING BEAUTY.
An abundant component of the mesic woods' spring flora.

POTAMOGETONACEAE (PONDWEED FAMILY)

Potamogeton amplifolius Tuckerman. LARGE-LEAVED PONDWEED.
A common aquatic plant especially prevalent in deep water of most lakes.

Potamogeton alpinus Balbis var. tenuifolius (Raf.) Ogden.
A local species collected from Little Beaver Lake.

Potamogeton epihydrus Raf. RIBBON-LEAVED PONDWEED.
An occasional species, known from several lakes in the park.

Potamogeton filiformis Pers.
Uncommon to occasional in several lakes.

Potamogeton foliosus Raf. LEAFY PONDWEED.
Little Beaver Lake, locally abundant.

Potamogeton friesii Rupr. FRIES' PONDWEED.
Scarce to occasional in several lakes.

Potamogeton gramineus L. GRASS-LEAVED PONDWEED.
Common in most lakes.

Potamogeton natans L. COMMON PONDWEED.
Common in most lakes.

Potamogeton obtusifolius Mert. & Koch.
Little Beaver Lake: local near mouth of cold spring.

Potamogeton praelongus Wulfen. WHITE-STEMMED PONDWEED.
Local, east side of Grand Sable Lake.

Potamogeton pusillus L. SMALL PONDWEED.
Local in several lakes in the park.

Potamogeton richardsonii (Benn.) Rydb. RICHARDSON'S PONDWEED.
An abundant species in most lakes.

Potamogeton robbinsii Oakes. FERN PONDWEED.
An abundant species in most lakes.

Potamogeton strictifolius Bennett. STIFF PONDWEED.
Local to uncommon in several lakes.

Potamogeton vaginatus Turcz.
An uncommon species observed and collected at the outlet to Miners Lake.

Potamogeton zosteriformis Fern. FLAT-STEMMED PONDWEED.
An abundant species in most lakes.

PRIMULACEAE (PRIMROSE FAMILY)

Lysimachia terrestris (L.) BSP. SWAMP CANDLES.
Occasional on lake edges.

Lysimachia thyrsiflora L. TUFTED LOOSESTRIFE.
Seen and collected only in marsh of Miners Lake.

Primula mistassinica Michx. [incl. P. intercedens Fern.]. BIRD'S EYE PRIMROSE.
Common on damp to dripping sandstone cliffs of the Pictured Rocks.

*Trientalis borealis Raf. STARFLOWER.
A common plant found in many habitats from cedar swamps to mixed woodlands.

PYROLACEAE (WINTERGREEN FAMILY)

Chimaphila umbellata (L.) Bart. PRINCE'S-PINE, PIPSISSEWA.
Most common in dry sandy habitats under pines.

Moneses uniflora (L.) Gray. ONE-FLOWERED PYROLA.
Occasional in cedar swamps and other wet boggy woods.

Monotropa hypopithys L. PINESAP.
Seen and collected only from a second-growth beech-maple woods near Chapel Lake.

*Monotropa uniflora L. INDIAN PIPE.
Common in coniferous to deciduous upland woods.

Pyrola asarifolia Michx. PINK SHINLEAF.
Common in sandy woods to rich mixed woods.

Pyrola elliptica Nutt. LARGE-LEAVED SHINLEAF.
A local species in dry pineland to rich mixed ravines.

Pyrola minor L. SMALL SHINLEAF.
Very local in jack pine flats on the Grand Sable Dunes and in conifer habitats near the coast.

Pyrola secunda L. ONE-SIDED SHINLEAF.
Common in most wooded habitats.

Pyrola virens Schweigger. GREEN SHINLEAF.
Common in many wooded habitats but mostly seen in rich mixed woods behind dunes and in protected ravines.

RANUNCULACEAE (BUTTERCUP FAMILY)

Actaea pachypoda Ell. WHITE BANEBERRY.
Occasional to common in rich deciduous woods.

Actaea rubra (Ait.) Willd. RED BANEBERRY.
Occasional to common in deciduous woodland. More frequent than preceding species.

Anemone canadensis L. MEADOW ANEMONE.
Found in somewhat open damp sites such as on stream banks.

*Caltha palustris L. MARSH-MARIGOLD.
Common in marshy areas, stream banks and alder thickets.

Clematis virginiana L. VIRGIN'S BOWER.
A fairly common species in a variety of lowland habitats.

Coptis groenlandica (Oeder) Fern. [included in C. trifolia by Gleason and Cronquist]. GOLDTHREAD.
Common in cedar swamps as well as on winter beaches and stabilized shorelines of Lake Superior.

Ranunculus abortivus L. SMALL-FLOWERED BUTTERCUP.
A locally frequent species in deciduous woods.

Ranunculus acris L. TALL BUTTERCUP.
An all-too-common weed in fields and along roadsides.

Ranunculus circinatus Sibth. WHITE WATER CROWFOOT.
Locally common in lakes.

Ranunculus longirostris Godr. [R. circinatus? sen. lat.]. STIFF WATER CROWFOOT.
Locally common in Chapel Lake. Perhaps not a distinct species from *Ranunculus circinatus.*

Ranunculus recurvatus Poir. HOOKED BUTTERCUP.
A species of wet to wet-mesic boggy woods.

Ranunculus reptans L. CREEPING SPEARWORT.
A locally common species growing on sandy lake bottoms, shores and on floating logs.

Ranunculus septentrionalis Poir. SWAMP BUTTERCUP.
A species of wet to mesic woods.

Ranunculus trichophyllus Chaix. [=R. aquatilis L. var. capillaceus (Thuill.) DC.]. WHITE WATER CROWFOOT.
Found in quiet waters of lakes and small ponds.

Thalictrum dasycarpum Fisch. & Lall. PURPLE MEADOW-RUE.
Occasional in damp places such as stream sides.

RHAMNACEAE (BUCKTHORN FAMILY)

Rhamnus alnifolia L'Hér. ALDER BUCKTHORN.
Occasional to common in alder thickets, bogs and marshes.

ROSACEAE (ROSE FAMILY)

Agrimonia striata Michx. GROOVED AGRIMONY.
Collected on the edge of beech-sugar maple woods near Miners Castle.

Amelanchier arborea (Michx. f.) Fern. JUNEBERRY.
Found throughout park in a variety of habitats, often in more or less open areas on sandy substrate.

Amelanchier bartramiana (Tausch.) Roem. MOUNTAIN JUNEBERRY.
Found infrequently in open sandy areas, such as on storm beach of Miners Beach.

Amelanchier laevis Wieg. ALLEGHENY SHADBLOW.
Common in open to semi-open areas.

Aronia prunifolia (Marsh.) Rehd. [=Pyrus floribunda Lindl. of Gray's Manual]. CHOKEBERRY.
In moist beach depressions on Sand Point; occasional.

Crataegus douglasii Lindl. HAWTHORN.
A rare hawthorn in the park, known from the Grand Sable Dune area; it has also been collected on Grand Island near the park. This species is another example of a Rocky Mountain plant having a disjunct range in the upper Great Lakes region.

*Fragaria virginiana Duchesne. STRAWBERRY.
Common in semi-open to open sandy areas.

Geum aleppicum Jacq. var. strictum (Ait.) Fern. YELLOW AVENS.
A species of damp thickets and marshes.

Geum canadense Jacq. WHITE AVENS.
Occurs in wet-mesic to mesic woods.

Geum macrophyllum Willd.
Common especially in the vicinity of Miners Castle and Miners Falls in disturbed openings.

Geum rivale L. PURPLE AVENS.
Seen and collected only once along trail west of Miners Castle area.

Physocarpus opulifolius (L.) Maxim. NINEBARK.
Common along the Miners River. This species is often planted in such habitats to enhance wildlife management aspects of streams so these may not be spontaneous.

Potentilla anserina L. SILVERWEED.
Uncommon on damp sand beaches.

Potentilla argentea L. SILVERY CINQUEFOIL.
An occasional weed in disturbed places and lawns.

Potentilla palustris (L.) Scop. MARSH CINQUEFOIL.
Common in marshes and bogs.

Potentilla recta L. SULFUR CINQUEFOIL.
An occasional weed of roadsides, dry fields and disturbed places.

Potentilla tridentata Ait. THREE-TOOTHED CINQUEFOIL.
Uncommon in dry, usually open sandy soil.

Prunus pensylvanica L. f. PIN CHERRY.
A common small tree or shrub in sandy soil of pine barrens, pine woods and the winter beach of Lake Superior.

Prunus pumila L. SAND CHERRY.
A common species in sandy open habitats of dunes and beaches, as well as in pine barrens.

Prunus virginiana L. CHOKE CHERRY.
A common species in deciduous woods and on forest edges in thickets.

Pyrus americana and Pyrus decora (see Sorbus).

Pyrus floribunda (see Aronia).

*Pyrus malus L. APPLE.
Persisting around sites of old residences.

Rosa blanda Ait. WILD ROSE.
Locally common on forest edges and in sandy openings.

Rosa palustris Marsh. SWAMP ROSE.
Locally frequent in marshes and open bogs.

Rubus allegheniensis Porter. COMMON BLACKBERRY.
A thicket species of openings and roadsides.

Rubus parviflorus Nutt. THIMBLEBERRY.
Occasional but locally frequent along roadsides, in openings and mixed woods. A member of the western disjunct group of plants occurring in the upper Great Lakes region.

Rubus pubescens Raf. DWARF RASPBERRY.
A common species of cedar swamps and wet woods.

Rubus strigosus Michx. RED RASPBERRY.
Occasional to common in openings to lightly wooded well-drained soils.

Sorbus americana Marsh. [=Pyrus americana]. AMERICAN MOUNTAIN ASH.
Occasional in mixed to conifer woods, and on cliff ledges.

Sorbus decora (Sarg.) Schneid. [=Pyrus decora]. SHOWY MOUNTAIN ASH.
Similar habitats as the previous, apparently more common than *S. americana.*

RUBIACEAE (MADDER FAMILY)

Galium asprellum Michx. ROUGH BEDSTRAW.
Found in open sunny thickets.

Galium tinctorium L. STIFF BEDSTRAW.
A species of marshes and bogs. The closely allied *G. trifidum* probably also occurs in the park in similar habitats but was not collected.

Galium triflorum Michx. SWEET-SCENTED BEDSTRAW.
A common species of all types of upland woods.

Mitchella repens L. PARTRIDGE BERRY.
An occasional to common species in beech-maple woods.

SALICACEAE (WILLOW FAMILY)

*Populus balsamifera L. BALSAM POPLAR.
A common species in many habitats throughout park, most commonly in dunes, fields and woodland borders.

Populus grandidentata Michx. LARGE-TOOTHED ASPEN.
A common species in more or less open woods and fields.

Populus tremuloides Michx. QUAKING ASPEN.
An abundant species everywhere in the park.

Salix bebbiana Sarg. BEAKED WILLOW.
Common shrub to small tree in most wet habitats.

Salix candida Flügge. HOARY WILLOW.
Collected from a swamp near Munising where it was reported as abundant in 1916 by C. K. Dodge. Undoubtedly to be found in similar situations today though not recorded by me.

Salix cordata Michx. [=S. syrticola of Gray's Manual]. DUNE WILLOW.
Common species on Grand Sable Dunes.

Salix discolor Muhl. PUSSY WILLOW.
Common in many types of damp to wet habitats.

Salix humilis Marsh. PRAIRIE WILLOW.
Sable Banks near Grand Marais. Plentiful. Collected by C. K. Dodge (1916). Not seen in field by me.

Salix interior Rowlee. SANDBAR WILLOW.
On the Grand Sable Dunes; also to be found along streams and wet places.

Salix lucida Muhl. SHINING WILLOW.
Common in many damp to wet habitats.

Salix petiolaris Smith. [=S. gracilis Anderss., in part]. PETIOLED WILLOW.
Found in wet to damp areas from marshes to old logging roads.

Salix syrticola Fern. (see S. cordata).

SANTALACEAE (SANDALWOOD FAMILY)

Comandra umbellata (L.) Nutt. [incl. C. richardsiana Fern.]. FALSE TOADFLAX.
Fairly common in damp to dry sandy areas of Lake Superior shoreline.

Geocaulon lividum (Richards.) Fern. NORTHERN COMANDRA.
Occasional under jack pines in stabilized sand of Grand Sable Dunes.

SARRACENIACEAE (PITCHER-PLANT FAMILY)

Sarracenia purpurea L. PITCHER-PLANT.
A common species in open sphagnum bogs.

SAXIFRAGACEAE (SAXIFRAGE FAMILY)

Chrysosplenium americanum Schw. GOLDEN SAXIFRAGE.
A small semi-aquatic having an affinity for cold seepy habitats.

Mitella nuda L. SMALL BISHOP'S CAP.
A common species of wet boggy woods to rich mesic woods.

Parnassia parviflora DC. SMALL GRASS-OF-PARNASSUS.
Grows in rock crevices along the shore of Lake Superior.

Ribes cynosbati L. PRICKLY WILD GOOSEBERRY.
Occasional in wet-mesic to mesic woods and in border thickets.

Ribes lacustre (Pers.) Poir. BRISTLY BLACK CURRANT.
Occasional in maple-hemlock woods and openings; also in cedar swamps.

Ribes triste Pall. RED CURRANT.
Occasional to common in cedar swamps to mixed woods and ravines.

Tiarella cordifolia L. FOAM FLOWER.
An uncommon species in beech-maple-hemlock woods.

SCROPHULARIACEAE (FIGWORT FAMILY)

Chelone glabra L. TURTLEHEAD.
An occasional species of marshes and lakeshores.

Linaria vulgaris Hill. BUTTER-AND-EGGS.
A weed of roadsides.

Melampyrum lineare Desr. COW-WHEAT.
An abundant species in sandy areas under pines.

Mimulus moschatus Dougl. MUSKFLOWER.
Wet open or partially shaded places near Grand Marais. Also in ditches in vicinity of Grand Marais. (See Dodge, 1918a.)

*Mimulus ringens L. MONKEY FLOWER.
Recorded only from the shoreline of Grand Sable Lake; the species undoubtedly occurs in similar habitats throughout the park.

Scrophularia lanceolata Pursh. EARLY FIGWORT.
Occasional in openings of deciduous woods, as along logging roads.

Verbascum thapsus L. COMMON MULLEIN.
A weedy roadside species.

Veronica chamaedrys L. GERMANDER SPEEDWELL.
An occasional to common weed in sand and fields around Sand Point and Munising Falls.

Veronica officinalis L. COMMON SPEEDWELL.
Uncommon in sandy areas of former residences.

Veronica scutellata L. MARSH SPEEDWELL.
A rare species collected and seen only on the edge of Little Chapel Lake.

Veronica serpyllifolia L. THYME-LEAVED SPEEDWELL.
A common species around old cottages.

SOLANACEAE (NIGHTSHADE FAMILY)

Physalis heterophylla Nees. CLAMMY GROUND-CHERRY.
Not common in sandy disturbed places.

Solanum nigrum L. BLACK NIGHTSHADE.
Collected in the sandy road from Melstrand to Chapel Falls, outside the park but probably occurring within also.

SPARGANIACEAE (BUR-REED FAMILY)

Sparganium americanum Nutt. AMERICAN BUR-REED.
Common in shallow water of Little Beaver Lake.

Sparganium angustifolium Michaux. NARROW-LEAVED BUR-REED.
Local in Little Beaver Lake; also seen in several other lakes and slow flowing rivers.

Sparganium chlorocarpum Rydb.
Occasional in many aquatic habitats.

Sparganium fluctuans (Morong.) Robinson.
Common in most lakes of park.

Sparganium minimum (Hartman) Fries. SMALL BUR-REED.
Occasional in lakes, bogs and alder thickets.

TAXACEAE (YEW FAMILY)

Taxus canadensis Marsh. CANADIAN YEW.
Locally common in rich deciduous to mixed woods.

TILIACEAE (LINDEN FAMILY)

*Tilia americana L. BASSWOOD.
A common tree of mesic woods.

TYPHACEAE (CAT-TAIL FAMILY)

Typha latifolia L. COMMON CAT-TAIL.
Occasional to common in marshes and on lakeshores.

ULMACEAE (ELM FAMILY)

Ulmus americana L. AMERICAN ELM.
Occasional tree, usually along streams and rivers.

UMBELLIFERAE (PARSLEY FAMILY)

Cicuta bulbifera L. BULBLET-BEARING WATER-HEMLOCK.
A fairly common species of open marshes and streamsides.

Cicuta maculata L. WATER-HEMLOCK.
Less abundant than the previous species, in the same habitats.

*Daucus carota L. WILD CARROT, QUEEN ANNE'S LACE.
A weed of roadsides and old fields.

Heracleum maximum Bartr. [=Heracleum lanatum Michx.]. COW-PARSNIP.
Common along roadsides and on stream banks.

Osmorhiza chilensis H. & A.
Occasional to common (?) in deciduous woodland and jack pine flats.

Osmorhiza claytonii (Michx.) C. B. Clarke. HAIRY SWEET CICELY.
A common species in deciduous woodland.

Osmorhiza obtusa (C. & R.) Fern. SWEET CICELY.
A common to abundant species of deciduous woods. Closely allied to *O. chilensis* and often difficult to tell apart.

Pastinaca sativa L. WILD PARSNIP.
An unfortunately too common weed of roadsides.

Sanicula marilandica L. BLACK SNAKEROOT.
An occasional species in mixed and deciduous rich woods.

Sium suave Walt. WATER PARSNIP.
Seen and collected only once in a shaded pond near Big Beaver Lake.

URTICACEAE (NETTLE FAMILY)

Laportea canadensis (L.) Wedd. WOOD NETTLE.
Occasional in wet to wet-mesic woods, usually in river bottoms.

Urtica dioica L. var. procera (Willd.) Wedd. TALL NETTLE.
Most commonly in disturbed conditions and on damp woodland borders.

VERBENACEAE (VERVAIN FAMILY)

Verbena bracteata Lag. & Rodr. CREEPING VERVAIN.
Collected on the sandy road from Melstrand to Chapel Falls, out of the park boundary but probably occurring within also.

Verbena hastata L. BLUE VERVAIN.
Occasional on damp sandy flats and in marshes.

Verbena urticifolia L. WHITE VERVAIN.
A woodland border plant found most commonly in the Chapel Lake area.

VIOLACEAE (VIOLET FAMILY)

Viola canadensis L. CANADA VIOLET.
An abundant species in beech-maple woods.

Viola conspersa Reichenb. DOG VIOLET.
A species of damp sand and cedar swamps.

Viola cucullata Ait. HOODED VIOLET.
Found in a variety of moist shaded habitats.

Viola incognita Brain.
Apparently uncommon in rich deciduous woods.

Viola lanceolata L. LANCE-LEAVED VIOLET.
Collected and most commonly seen in open sandy logging roads.

Viola macloskeyi Lloyd subsp. pallens (Banks) M. S. Baker. [=V. pallens (Banks) Brain.]. SMOOTH WHITE VIOLET.
Collected in sphagnum mat of large semi-open swamp northeast of Big Beaver Lake.

Viola pubescens Ait. [incl. V. pensylvanica Michx.]. YELLOW VIOLET.
Common in deciduous woods as in vicinity of Miners Castle.

Viola selkirkii Pursh.
Grows most commonly under hemlocks on rotting logs.

VITACEAE (VINE FAMILY)

Parthenocissus inserta (Kerner) K. Fritsch. THICKET CREEPER.
Occasional in rich woods to thickets.

ZOSTERACEAE (see Potamogetonaceae)

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Fig. 4. Miners Castle, long a landmark in the Pictured Rocks region. Until recently, this was the only known station in the region for black crowberry, *Empetrum nigrum*.

LICHENS OF THE MACKINAC STRAITS REGION. I. THE *CLADONIA CARIOSA* GROUP

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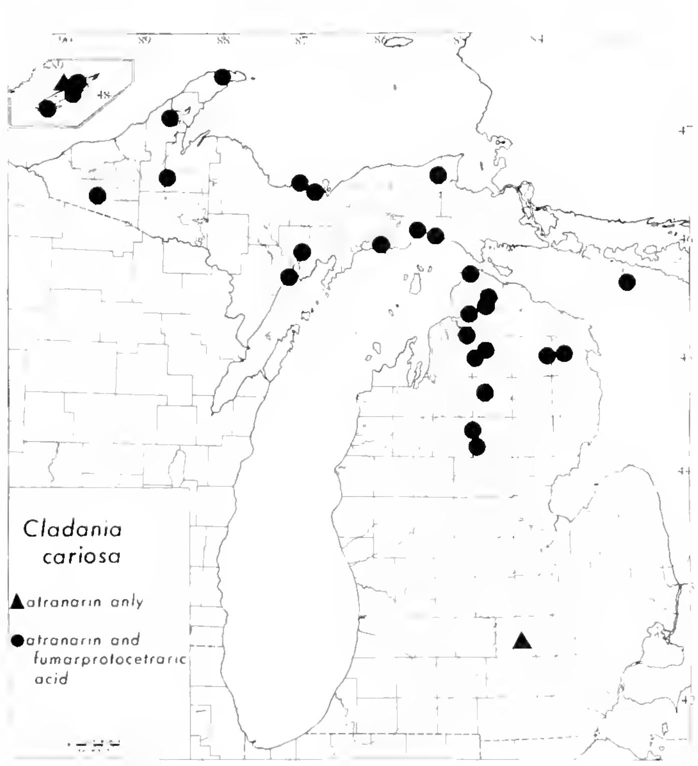
Culberson (1969) has revised the systematics of some of the members of the *Cladonia cariosa* group (=*Cladonia* series *Helopodium* (Ach.) Matt.) in North America. His study concentrated mainly on the southern species (*C. polycarpia* Merr., *C. polycarpoides* Nyl., and *C. subcariosa* Nyl.) and treated more northern species (*C. cariosa* (Ach.) Spreng. and *C. symphycarpa* (Ach.) Fr.) in a more superficial manner. In the course of revising material from the herbarium of the University of Michigan Biological Station, I found two chemical variants not included in Culberson's (1969) treatment. In order to fill in the picture, additional material in the University of Michigan Herbarium and in the Cryptogamic Herbarium of Michigan State University was studied. All of the specimens were analyzed by thin layer chromatography (Eastman silica gel 6060 with fluorescent indicator, benzene: dioxane: acetic acid, 90:25:4).

The first chemical variant discovered was one of *C. cariosa* itself. *Cladonia cariosa* has been considered to contain only atranorin, although both Sandstede (1938) and Thomson (1967) recognized that some specimens were PD+ red (indicating the probable presence of fumarprotocetraric acid) and Dahl & Krog (1973) recognized fumarprotocetraric acid as sometimes present in Scandinavian material. In Michigan *C. cariosa* containing atranorin only is very rare (Fig. 1), while the variant containing atranorin, fumarprotocetraric acid, and two unidentified substances (probably fatty acids) is common (Fig. 1). As far as I am able to judge, the two chemical variants are morphologically indistinguishable. Based on examination of non-Michigan material, they have a similar distribution, occurring in the northern United States and Canada from New England to Alaska. The variant containing atranorin alone may be more common in Europe as evidenced by the fact that only a single specimen from Finland of the ones I have analyzed contained fumarprotocetraric acid. (This broader survey also revealed another variant of *C. cariosa,* not treated here, in Arizona, Colorado, New Mexico, Utah, and Wyoming containing atranorin and another substance which microchemical tests suggest is homosekikaic acid.) The Michigan distribution of *C. cariosa* (Fig. 1) shows its northern affinities as indicated by Culberson (1969).

Distribution (atranorin only): MICHIGAN–Ingham and Keweenaw Counties. (atranorin and fumarprotocetraric acid): ONTARIO–Manitoulin District. MICHIGAN–Alger, Alpena, Baraga, Charlevoix, Cheboygan, Crawford, Delta, Emmet, Gogebic, Houghton, Luce, Mackinac, Montmorency, Otsego, Roscommon, and Schoolcraft Counties.

The second chemical variant of interest contains atranorin and psoromic acid. Although I collected material of this taxon while at the Biological Station in 1967, I incorrectly referred it to *C. norrlinii* Vain. on the basis of its chemistry. However, abundantly fertile material collected in 1974 led to restudy of the problem and made it clear that the taxon was a member of the *C. cariosa* group. It differs morphologically from *C. cariosa* in that the primary squamules are larger and more upright or even recurved so that the white underside is conspicuous. The podetia are coarser, more irregular, somewhat inflated and darker in color. The apothecia are smaller and more numerous. The material seems to me to be morphologically identical to European collections of *C. symphycarpa.* However, *C. symphycarpa* s. str. differs chemically in producing atranorin and norstictic acid. It is interesting to note that the morphologically indistinguishable species-pair of *C. acuminata* (Ach.) Norrl. and *C. norrlinii* shows this same chemical shift. *Cladonia symphycarpa* containing norstictic acid has not been found in Michigan. Culberson (1969) reports it from Colorado, Kansas, and Wisconsin. Thus far the psoromic acid variant is definitely known only from the Great Lakes region (Fig. 2) and has a rather northern distribution within the region. It seems to be quite common in the Straits region and at one site in Emmet County it is extremely abundant, forming mats covering many square inches. The apparent similarity of habitat requirements for some members of the *C. cariosa* group is also shown at this site since *C. cariosa* and *C. polycarpoides* were collected along with *C. symphycarpa. Cladonia acuminata* was also very abundant and has been collected several other times in association with *C. cariosa* and *C. symphycarpa* in the Straits region. Although the psoromic acid variant is known certainly only from the Great Lakes region, it should be



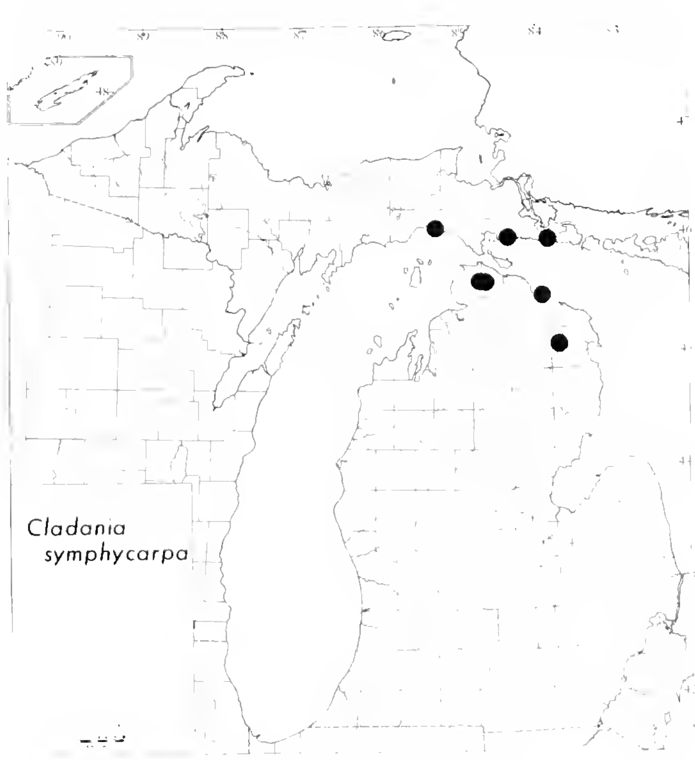


Fig. 1. Michigan distribution of *Cladionia cariosa* (triangles, atranorin only; circles, atranorin and fumarprotocetraric acid).

Fig. 2. Michigan distribution of *Cladonia symphycarpa*, psoromic acid variant.

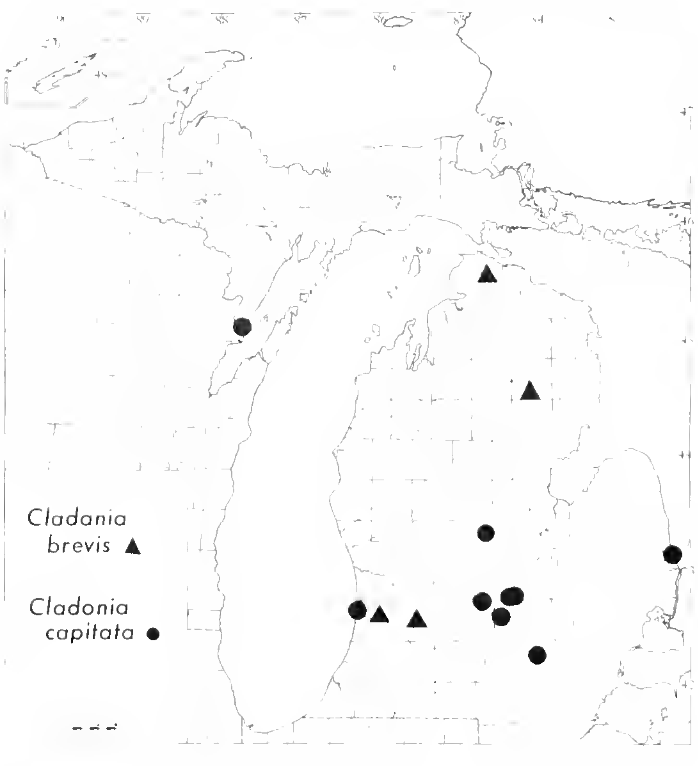
noted that Krog (1968) reported a PD+ yellow reaction in some Alaskan specimens of *C. cariosa,* possibly indicating the presence of psoromic acid, so that this variant may be more widespread.

Distribution: ONTARIO–Bruce County. MICHIGAN–Alpena, Cheboygan, Chippewa, Emmet, and Mackinac Counties.

These two additional chemical variants are of considerable interest since they fill in the gaps in the known distribution of chemical variation in the *C. cariosa* group (Table 1). The combination of atranorin and fumarprotocetraric acid was previously known in *C. apodocarpa* Robb., but this species is morphologically distinct from the bulk of the *C. cariosa* group in that the apothecia are borne directly on the primary squamules rather than on podetia. Most of the chemical variants in this group have been recognized at the species

TABLE I. The major lichen substances of the *Cladonia cariosa* group in North America.

	atranorin absent	atranorin present
no additional substances		C. cariosa (chem. var.)
fumarprotocetraric acid	C. capitata C. clavulifera C. nanodes	C. apodocarpa C. cariosa (chem. var.)
norstictic acid	C. polycarpoides	C. subcariosa C. symphycarpa (chem. var.)
norstictic acid stictic acid	C. polycarpia (chem. var., Culberson, 1969)	C. polycarpia (chem. var.)
psoromic acid	C. brevis	C. symphycarpa (chem. var.)



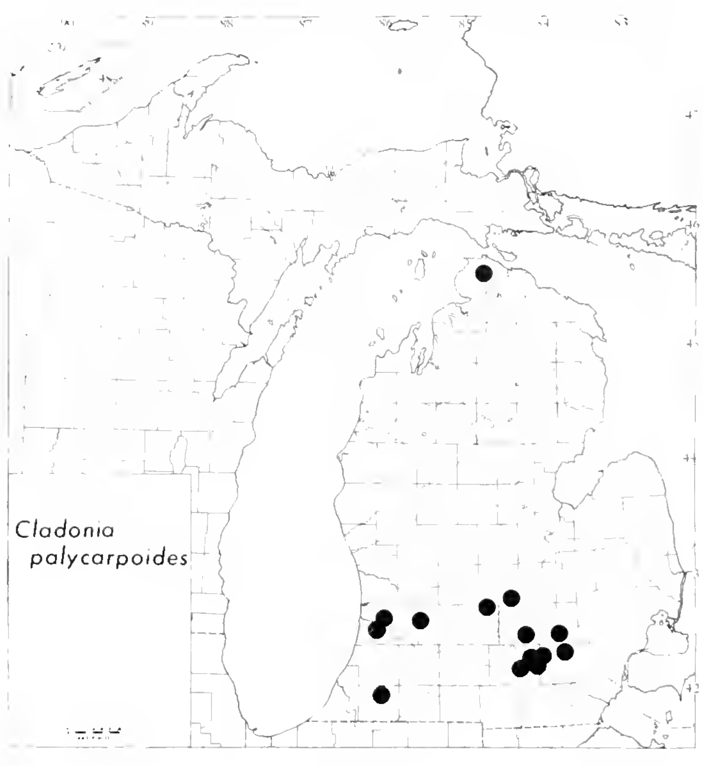


Fig. 3. Michigan distribution of *Cladonia brevis* (triangles) and *Cladonia capitata* (circles).
Fig. 4. Michigan distribution of *Cladonia polycarpoides.*

level. However, many of the taxa involved have not yet been typified, as Culberson (1969) has pointed out, and this paper is not a detailed study of the entire group. Therefore, I feel that formal recognition of any additional taxa would be inappropriate at this time.

In addition to the two taxa already discussed, which have a northern distribution in Michigan, there are three other members of the *C. cariosa* group known from Michigan. Two have a primarily southern distribution, while the third is too rare to show any pattern.

Cladonia capitata (Michx.) Spreng. (Fig. 3), with the exception of a collection from Menominee County, is confined to the southern half of the Lower Peninsula and has not been collected in the Straits region.

Distribution: MICHIGAN–Allegan, Clinton, Eaton, Gratiot, Ingham, Menominee, Saint Clair, and Washtenaw Counties.

Cladonia polycarpoides Nyl. (Fig. 4) is known from the southern third of the Lower Peninsula except for a single unexpected occurrence in Emmet County.

Distribution: MICHIGAN–Allegan, Barry, Cass, Clinton, Eaton, Emmet, Ingham, Jackson, Livingston, and Washtenaw Counties.

Cladonia brevis (Sandst.) Sandst. (Fig. 3) is known only from four localities in the Lower Peninsula, giving no indication of its distribution pattern. Thomson (1967) reports it from Labrador and New England to Wisconsin and south to Virginia.

Distribution: MICHIGAN–Allegan, Barry, Cheboygan, and Oscoda Counties.

The following key summarizes the chemistry and occurrence of the *C. cariosa* group in Michigan.

1. Podetia and squamules KOH+ yellow (atranorin present); northern Michigan 2
1. Podetia and squamules KOH– or KOH+ red (atranorin absent); Lower Peninsula only 4
    2. PD+ red (fumarprotocetraric acid present) . . . . . *C. cariosa*
    2. PD– or PD+ pale to dark yellow 3
3. PD+ yellow to dark yellow (atranorin and psoromic acid present); podetia coarse and irregular . . . . . *C. symphycarpa*
3. PD– or PD+ very pale yellow (atranorin only present) . . . . . *C. cariosa*
    4. PD+ red (fumarprotocetraric acid present); apothecia usually broader than the slender podetia . . . . . *C. capitata*
    4. PD+ yellow to dark yellow or pale orange 5
5. PD+ yellow (psoromic acid present) . . . . . *C. brevis*
5. PD+ pale orange (norstictic acid present) . . . . . *C. polycarpoides*

ACKNOWLEDGMENTS

I would like to acknowledge support from the University of Michigan Herbarium during the summer of 1974. Special thanks go to Dr. Howard Crum whose continuing encouragement and assistance have made this work possible. I also thank Dr. Henry Imshaug for permission to map collections from the Cryptogamic Herbarium, Michigan State University. This paper is a Contribution from the University of Michigan Biological Station.

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Publications of Interest

25 YEARS OF BOTANY 1947-1972. By W. H. Wagner, Jr., et al. Annals of the Missouri Botanical Garden Vol. 61, No. 1. 1974. 261 pp. $4.00. This special historical number of the Annals includes papers on mycology (Sparrow), phycology (Bold), lichenology (Thomson), bryology (Anderson), pteridology (Wagner), plant physiology (Ross & Salisbury), plant ecology (McIntosh), plant systematics (Raven), paleobotany (Andrews), paleopalynology (Traverse), and history of botany with a bibliographic appendix (Stuckey & Rudolph). Altogether, it constitutes a valuable summary of recent work in the various aspects of botany, informative to all of us who have not been able to keep up on the field since the days of our formal courses! It is always hard to offer a fair historical perspective so soon after events, but these authors have tried, with special reference to North America, and the papers are rich in references to significant publications and persons.

ACADEMIC & CURATORIAL BIOLOGISTS OF OHIO 1974-1975. Ed. by Glenn W. Peterjohn and Charles C. King. Ohio Biol. Surv. Informative Circ. 5. 1974. 30 pp. $1.00. A handy directory, listing institutions (with addresses and phones) and, within them, departments and staff, alphabetically, with academic titles and specific interests. The index lists institutions only and hence is largely redundant. Extremely useful would have been an index of *persons,* to aid one who knows only that he wishes to locate a colleague somewhere in Ohio. The title carries a snide and generally unwarranted implication that curators are not "academic."

BIBLIOGRAPHY OF OHIO PALEOBOTANY. By Robert C. Romans and Patricia S. McCann. Ohio Biol. Surv. Informative Circ. 6. 1974. 17 pp. $.50. Titles are listed alphabetically by author under headings of "General" and various geologic intervals.

BIBLIOGRAPHY OF THESES AND DISSERTATIONS ON OHIO FLORISTICS AND VEGETATION IN OHIO COLLEGES AND UNIVERSITIES. By Marvin L. Roberts and Ronald L. Stuckey. Ohio Biol. Surv. Informative Circ. 7. 1974. 92 pp. $1.50. Organization is by county, preceded by a "General" section; there are indexes to plant names and key words in titles, general topics, and authors. References are entirely to 344 undergraduate and graduate theses "on the topics of floristics, vegetation, plant ecology, and phytogeography for the State of Ohio. Only those theses and dissertations completed in Ohio colleges and universities are listed." Many of these have subsequently been published, sometimes in more or less modified form, but such publications are in no instances cited.

Note: The publications of the Ohio Biological Survey are available from OSU Publication Sales, Room 20 Lord Hall, 124 W. 17th Ave., Columbus, Ohio 43210.

BEHAVIORAL ASPECTS OF BENTHIC COMMUNITIES OF FILAMENTOUS BLUE-GREEN ALGAE IN LENTIC HABITATS

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INTRODUCTION

Very little attention has been paid to the behavior of communities of filamentous blue-green algae found at the bottom of lentic habitats (Fritsch, 1945; Schwabe, 1962, 1964; Whitton, 1973). The continuing trend toward eutrophication of southern Michigan lakes and ponds underscores the importance of the benthic component of the aquatic ecosystem, although it is frequently overlooked or discounted.

We have observed several genera which contributed to the formation of benthic cyanophyte assemblages, including *Cylindrospermum, Lyngbya, Nostoc, Oscillatoria, Phormidium, Spirulina,* and *Symploca.* These aggregations of frequently motile trichomes occur on the bottom of the lentic habitats in the euphotic zone where large populations may form a continuous mat on the bottom.

The behavior of the cyanophyte mat during periods of illumination (and photosynthesis) and its relationship to deteriorating water quality constitute the focus of this communication.

MATERIALS AND METHODS

Direct field observations of benthic filamentous blue-green algae were conducted in Wintergreen Lake, Gull Lake, and various ponds constructed on the grounds of the Kellogg Biological Station of Michigan State University. Attempts were made to simulate the natural habitat of some of these algal communities using 10-gallon aquaria containing water and screened sediment from the site of collection. Feral collections of *Oscillatoria curviceps* were made in both Wintergreen and Gull Lakes and found to be essentially unialgal. This alga was selected for laboratory experiments because of its abundance, its rapid gliding rate (4-6 μm sec^{-1}), and its resistance to handling and manipulation.

The aquaria used in this study contained sand from the east shore of Gull Lake which was passed through a standard window screen and added to a depth of 5 cm. The aquaria were filled to a depth of 24 cm with screened lake water and allowed to clear by settling prior to addition of *O. curviceps.* Continuous vertical illumination was supplied by cool-white fluorescent lamps at an intensity of 2000 lux. The pH was monitored at 12-hour intervals with a Coleman pH meter. The aquaria were held at room temperature. The chemical composition of the first 2 meters of water in Gull Lake on June 26, 1973, was as follows (values expressed in mg l^{-1}):

> Ca^{+2}, 42.37; K^{+1}, 1.15; NO_3^{-1}, 0.114; O_2, 8.58-8.70; Mg^{+2}, 17.78; SiO_2, 0.1-1.25; NO_2^{-1}, 0.006; Alkalinity, 150-154 (as $CaCO_3$); Na^{+1}, 6.67; NH_4^{+1}, 0.43; and PO_4^{-3}, 2.04-3.95 (as μg l^{-1}). (D. Tague, personal communication).

FIELD OBSERVATIONS

Several lentic freshwater habitats were observed which harbored large populations of filamentous blue-green algae in shallow waters. Photosynthetic activity during daylight resulted in the production of gas bubbles in the mat causing sections of the mat to float to the surface. These floating rafts of benthic algae were a common sight on Wintergreen Lake during late June, July, and August of 1972 and 1973 (Fig. 1). We observed similar floating masses of algae on lakes in Indiana, Ohio, and Wisconsin during the same seasons.

Floating sections of a benthic mat were composed of thousands of filaments intertwined in accumulated sheath material and considerable quantities of detritus (Fig. 2). No floating aggregations were present at the surface at daybreak but their frequency increased during the day. Those filaments capable of gliding movements usually moved to a position in the raft beneath the associated detritus within 30 minutes of surface exposure. This quickly changed the appearance of the floating clump from a dark blue-green to a muddy brown.

The size of the alga rafts varied with wave action, the population density of the benthic community, and the cyanophytes composing the community. *Cylindrospermum, Nostoc,* and *Spirulina* were responsible for numerous small rafts with limited detritus. The largest rafts observed were produced by *Oscillatoria* and *Lyngbya,* while *Symploca* and *Phormidium* were somewhat smaller and less frequent.

Downwind areas of lakes with extensive growths of benthic cyanophytes contained thousands of rafts concentrated by wind action during the day. These rafts later were dispersed by waves and currents, were washed up on shorelines, or sank during the night. The process of raft accumulations

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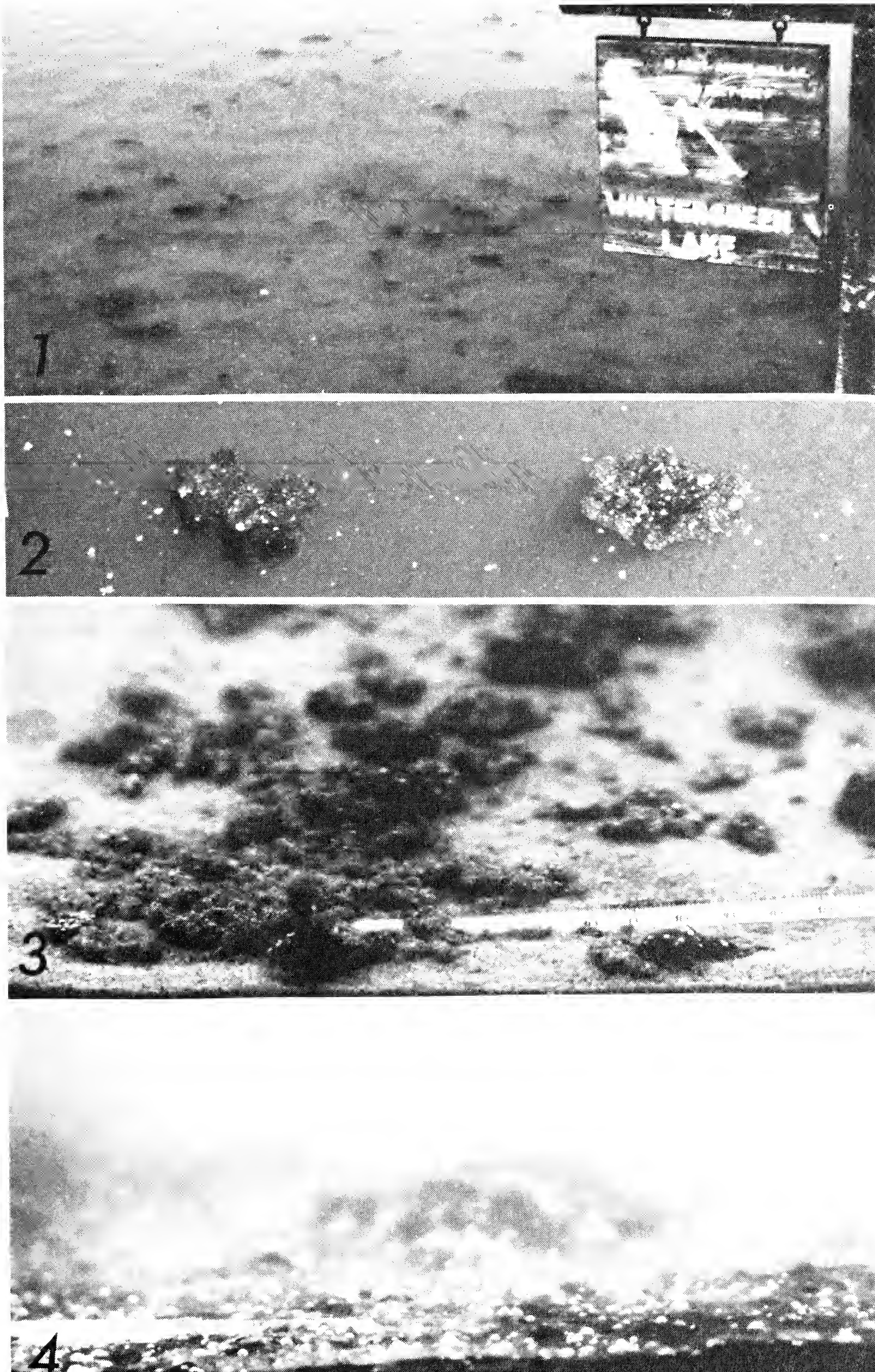
Fig. 1. A view of the surface of Wintergreen Lake in July of 1973 displaying numerous floating rafts of *O. curviceps* which detached from the bottom of the lake by 2:00 P.M.
Fig. 2. Two floating clumps of *O. curviceps* floating on Wintergreen Lake with scattered *Lemna minor.* These clumps have been at the surface long enough for filaments to have moved beneath the aggregation. The masses of algae are approximately 8 cm in diameter.
Fig. 3. Masses of feral *O. curviceps* immediately after being placed in the bottom of an aquarium water bath. Illumination was for photographic purposes only.
Fig. 4. A mat of *O. curviceps* established in an aquarium water bath which has been subjected to 2 hours of continuous illumination. A general distribution of bubbles has formed in the mat.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occurred within a few hours. Frequently, there was no evidence of a blue-green problem in the immediate area early in the same day. Death and decomposition of washed up masses of algae produced acutely objectionable odors.

LABORATORY OBSERVATIONS

Feral *Oscillatoria curviceps* from Gull Lake was introduced to aquaria containing screened sand and water from the same lake (Fig. 3). Twelve hours after introduction to the aquarium the motile filaments had spread over the entire substrate to form a continuous mat. A uniform distribution of small bubbles began to develop within 2 hours after the beginning of vertical illumination (Fig. 4). As illumination continued, segments of the mat became buoyant and began to detach from the substrate (Fig. 5). These segments of mat material completed their detachment and floated to the surface, carrying some of the substrate and marl precipitate with them (Fig. 6). The benthic mat was characterized by a disruption where the floating raft had detached (Fig. 7). The first mat section to rise to the surface did so approximately 6 hours after onset of illumination. Floating rafts of *O. curviceps* quickly adjusted to their sudden close proximity to the light source by gliding to the bottom of the clumps, beneath the associated sand and marl (Fig. 6).

The parallel between behavior in the field and in the laboratory was complete up to this point. The unexpected development derived from the aquaria models was the behavior of the motile filaments of *O. curviceps* once they accumulated underneath the floating section of mat. Several ropes of rapidly gliding filaments extended downward from each mass of algae (Fig. 8). The ropes were composed of hundreds of filaments which were heavily concentrated at the lowest point on the strand (Fig. 9). These strands gradually descended until lengths of 20 cm or more were observed (Fig. 10). Contact with the substrate was eventually re-established when the terminal cluster of filaments on the rope dispersed into the sand. This process occurred within 6 to 8 hours.

The material remaining in the floating mat was gradually diminished and sank after the majority of the *O. curviceps* descended from the raft. The marl deposits resulted from the gradual increase in pH noted during periods of illumination, a phenomenon attributed to algal photosynthesis (Fogg, 1969).

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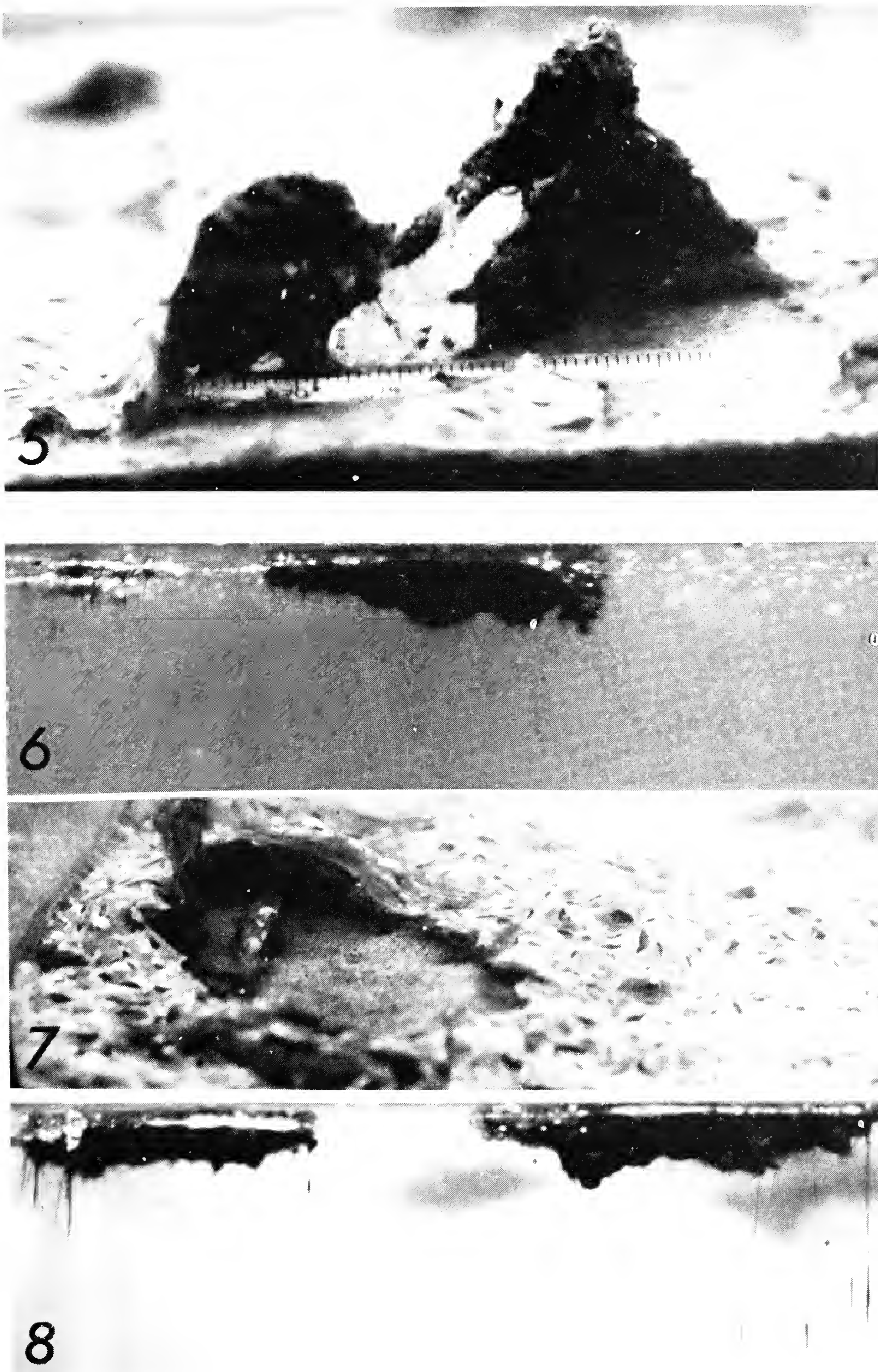
Fig. 5. Sections of the benthic mat beginning to detach from the remainder of the mat. The surface of the mat has become coated with a precipitate of marl resulting from a rise of pH following a period of approximately 4 hours of continuous illumination.

Fig. 6. A floating clump of *O. curviceps* approximately 8 cm in diameter which rose to the surface approximately 6 hours after the beginning of the photoperiod. Most filaments have moved to the bottom of the clump.

Fig. 7. A discontinuity created in the benthic mat by the detachment of a floating clump of *O. curviceps* which was shown in Figure 6. The marl precipitate is very evident here.

Fig. 8. Two rafts of blue-green algae which have begun to form ropes of filaments which are descending toward the substrate. The strands illustrated are approximately 6 cm long at 2 hours after arriving at the surface.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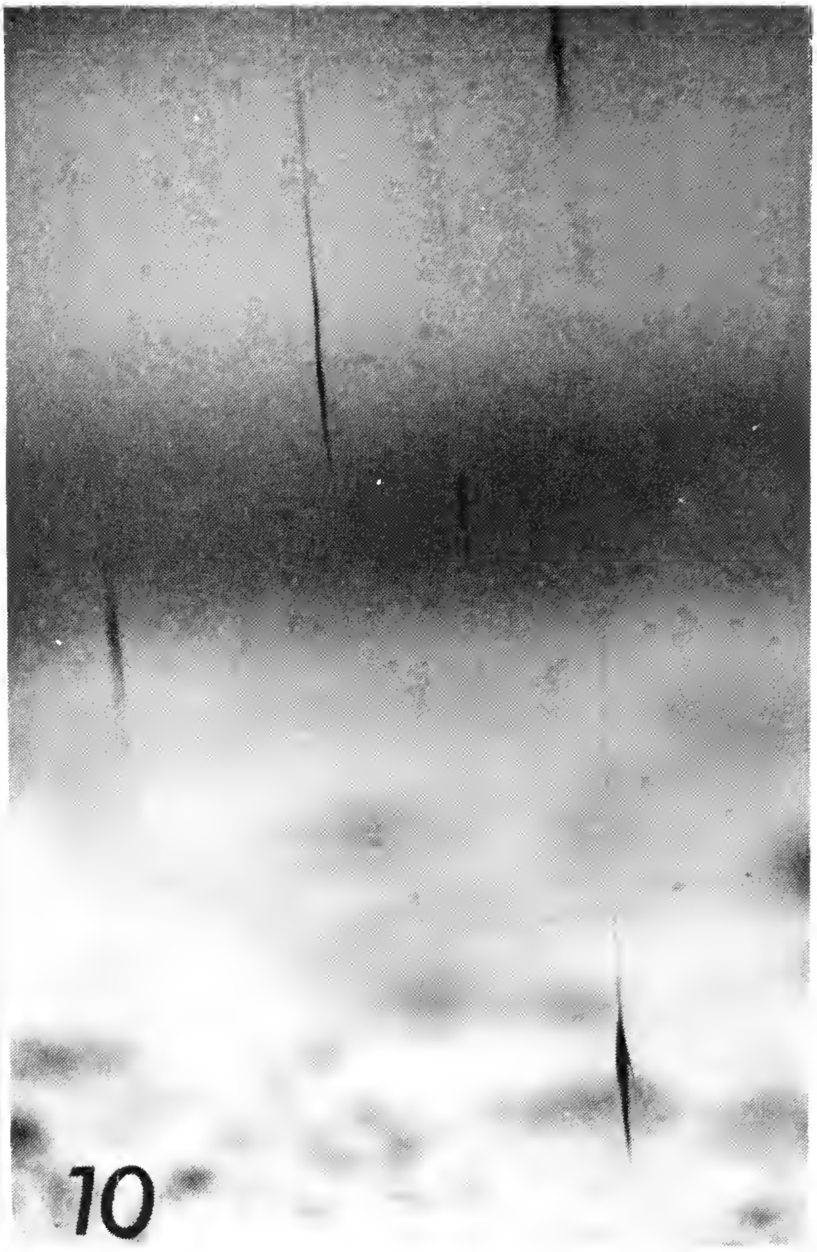

Fig. 9. Another view of ropes of filaments descending from a raft of *O. curviceps.* This raft has been floating 4 hours. The lowest cluster of filaments (see arrow) is approximately 12 cm beneath the clump.
Fig. 10. Terminal clusters of filaments of *O. curviceps* at the ends of ropes descending over 20 cm from a floating mass of algae. Substrate contact was established within 8 hours.

When the number of cyanophyte filaments was not large enough to form a mat, the alga would glide down into the sand. This phenomenon was observed in both aquaria and in sandy areas of Gull Lake. Stripping away sand from the bottom in these areas revealed bands of blue-green algae at depths up to 4 cm in the substrate. This algae-permeated layer of sand was frequently disturbed by escaping gas bubbles during the daylight period.

DISCUSSION

The detachment of sections of a benthic cyanophyte mat during periods of high photosynthetic activity may exert a significant influence on the aquatic ecosystem by exposing large amounts of sediment to oxygen-rich surface waters thereby facilitating mineralization by aerobic heterotrophic bacteria. This is in addition to the oxygen introduced directly into the bottom substrate by the mat organisms in shallow waters within the euphotic zone. This algae-bacteria community probably accelerates the recycling of sedimented nutrients and production of carbon dioxide which may stimulate growth of the blue-green population (Fogg, 1969) assuring rapid replacement of those sections of the mat which are lost by detachment and drift in the surface current.

The dispersal of algae from an established community is greatly enhanced by the disruption of the mat due to local increases in buoyancy. The mechanism described herein for *O. curviceps* illustrates how floating rafts of algae are able to adjust to environmental changes suddenly encountered at the surface of the lake.

The floating clumps of motile filaments experience a significant increase in light intensity, a temperature elevation, and possibly some form of wave activity. Previous studies have shown that motile blue-green algae may display negative phototrophic (Stanier et al., 1971; Nultsch, 1965; Castenholz, 1968) and negative thermotrophic (Castenholz, 1968) responses. These responses may be applied to the observed movement of filaments of *O. curviceps* to the bottom of the clump immediately after rising from the substrate. The formation of ropes of filaments extending down from the raft to the substrate is a logical extension of this reasoning. This mechanism allows the return of filaments to the benthic habitat in suitably shallow areas to initiate new communities of *O. curviceps* often at considerable distances from the original occurrence of the organism.

In conclusion, an increasing number of reports characterize the role of planktonic blue-green algae in water quality problems in increasingly eutrophic waters (Fogg, 1969; Whitton, 1973). The rapid accumulation of benthic blue-green algae at the surface of a shallow lake presents a special circumstance with respect to water quality because the benthic community is frequently overlooked when treatment programs are considered. Secondly, the massive accumulation of these algae rafts may often occur in regions of the water course distinctly removed from their point of origin.

Increasing difficulties with benthic blue-green algae are anticipated in littoral regions of increasingly fertile lakes with heavy recreational and/or residential pressures. Similarly, shallow artificial reservoirs and farm ponds create the conditions for the development of benthic blue-green algae especially if concerted efforts are made to prevent the development of aquatic macrophytes. Expanding recreational access to a lake by dredging channels also creates an ideal habitat for these organisms to proliferate.

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Reviews

PLANTS OF THE CHICAGO REGION. A Check List of the Vascular Flora of the Chicago Region with Notes on Local Distribution and Ecology. 2nd Ed. By Floyd Swink. Morton Arboretum, Lisle, Illinois 60632. 1974. 474 pp. $5.00 [+ $.50 postage], paper cover.

Scarcely five years after the first edition of this excellent local flora (reviewed in our May 1970 number), here is a completely new edition, accommodating about 80 additional species. There are a few more pages—but the sizes of page, type, and maps, and the price, have been reduced to a trifle over half those of the previous editions. The arrangement and format are as clear and useful as previously, the work appears to be as free of typographical errors, blooming dates have been added for many species, and over 2000 new county distribution records are incorporated in the maps. Maps have been deleted for some species if records now are known from all 22 counties covered (from southeastern Wisconsin to Berrien County, Michigan). Many other species are now mapped for which there were no maps before. Some alterations in nomenclature have been made, in common names as well as scientific. The fringed orchids are now "fringe orchids"—which almost makes them sound subversive—and *Habenaria clavellata* and *H. hyperborea* are still given such names even though they have no fringe at all.

—E.G.V.

CYTOTAXONOMICAL ATLAS OF THE SLOVENIAN FLORA. Cytotaxonomical Atlases Vol. 1. By Askell Löve and Doris Löve. J. Cramer, Lehre, Germany. 1974. 1241 pp. DM 200.00.

The authors have attempted to provide a uniform "biological" concept of the taxa and to apply the correct name regardless of the one under which previous work may have been reported. Thanks to their diligence, only about 140 taxa of the area covered (northern Yugoslavia) are unknown cytologically; so this work is a complete modern checklist of its vascular plants, with geographical information, appropriate synonymy, and references to reported chromosome numbers—all reproduced from computer printouts. There are an index and extensive bibliography.

We review a work apparently so far removed from the Great Lakes region in light of the authors' contention that "if a species is correctly identified and exactly and evolutionarily defined, then it has the same chromosome number from whatever locality or region the material for its cytological study has originated. This fact makes meaningless the requirement that chromosome numbers to be included in flora manuals must be determined from populations indigenous within the area concerned." Not all taxonomists will by any means accept this assertion, but for those who do, it is not surprising that the present Atlas includes counts based on material from the Great Lakes region—and that counts based on Yugoslavian material may be expected to be the same as for our plants.

—E. G. V.

Nature education feature --

MAPLE SYRUP–A FAMILY PROJECT

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Every person who enjoys the arrival of spring has his favorite harbinger to spark the enthusiasm accompanying the knowledge that spring is imminent. For many, it may be the hepatica's furry leaves; for others, it may be the appearance of the first robin on a patch of green grass surrounded by a snow-covered lawn or the swollen buds of the silver maple. Some of us look for an even earlier sign to rekindle this annual interest in returning to the out-of-doors. For us, it is the return of bright, sunny days accompanied by freezing nights in late January which signals the time for renewal of one of the oldest early spring practices in the northern United States, the conversion of maple sap into maple syrup.

In this article, we share some of the techniques, observations, and knowledge which we have gained in several years of operating a small sugar bush near Ann Arbor, Michigan. Started as a family project, we found quickly that maple syrup production could be a fascinating educational activity involving a broad spectrum of skills, from selecting and tapping trees to the final grading of the finished syrup as to color and sugar content.

Equally interesting has been the study of the lore of sugaring. Historically, maple syrup is one of the oldest forest product commodities produced in Michigan and the United States. The American Indian generally is given credit for discovering the conversion of maple sap into maple syrup. Henry R. Schoolcraft (1884, p. 199) described the spring ritual of sugar making as "a sort of Indian carnival . . . a season of hilarity and feasting." The Michigan Indian apparently used pots of birch bark or hollowed-out logs and made the sap boil by throwing in red-hot stones. Another report indicates that some Indians converted sap into syrup by allowing the sap to freeze overnight, throwing off the ice and collecting the thick syrup that was left (Nearing 1970). The early Michigan settlers, after learning the techniques from the Indian, provided many innovations. They found that boring holes and inserting spiles instead of gashing the trees, as the Indians had done, was much less wasteful. The use of metal boiling pots and sap buckets also increased the efficiency of the operation.

While Michigan generally ranks fourth or fifth in annual production, behind Vermont, New York, Ohio, and Pennsylvania, maple-syrup production has declined in Michigan and the United States since 1918, and today contributes little to our state's economy. According to a 1970 report (Nyland & Rudolph), "in 1949, nearly 3000 farms in 68 lower peninsula counties realized some farm income from maple syrup, but between 1949 and 1964, the number dropped to 810 farms in 63 counties." While the 1970 report predicted a possible further drop in Michigan maple-syrup production, the current price of sugar and sugar products, as well as a renewed interest in early Americana, may stimulate many to consider again this source of sugar.

Of the several species of maple trees growing in Michigan, the two most commonly selected for sap are sugar maple (*Acer saccharum*) and black maple (*Acer nigrum*). Sap suited to syrup conversion may be obtained from red maple (*Acer rubrum*) and silver maple (*Acer saccharinum*). These latter two, however, usually yield a sap of lower sugar content and an inferior grade of syrup. This is especially true if the sap is collected during the time when the red and silver maple buds break their dormancy, a period which is usually well ahead of the sugar and black maple. In some instances, the silver maple is tapped early because the sap flows more freely at that time than the sugar maple does. Often silver maple sap is mixed with sugar maple sap to produce a more satisfactory syrup. Box-elder (*Acer negundo*) sap is reported suitable for syrup conversion; however, we have had no experience with this tree species. (See also Hanes, 1954.)

Within the sugar maple species, there is a wide variation in the sugar content of sap, ranging from 2% to as much as 12%. Tree genetics, size of crown, height of tree (especially trunk length), age, seasonal conditions, and general health of the tree all probably contribute to this variation. James W. Marvin and Fred H. Taylor, Department of Botany, University of Vermont, are investigating the problem of selecting and domesticating wild sugar maples of high sugar yield. They hope to raise a faster growing productive strain that will yield a high sugar content sap (Nearing, 1970).

In selecting maples for tapping, choose trees with trunk diameter of at least ten inches at a height of three feet above the ground. Larger trees may be tapped in more than one place. We have followed the general rule of one bucket for a ten-inch tree and one additional bucket for each six-inch increase in diameter. Apparently, trees are not harmed by tapping. Some trees have been tapped in certain commercial sugar bushes almost continuously for 150 years with the trees still showing growth. Tapping the trees may begin as early as January with most tapping completed by February 15 in the Lower Peninsula. We have found the quality of the syrup to be superior when produced from sap collected in January, so we try to tap as soon as we experience a weather pattern of warm, sunny days with temperatures rising above freezing followed by freezing nights.

The tap itself should be located at a spot on the trunk about two to four feet above the ground in good sound wood. We have found that taps located on the south-facing side of the trees tend to produce a greater sap yield. This is due, possibly, to the warmer temperatures generated in the sap-conducting vessels (phloem) on that side. Drill a hole with a 7/16 or 1/2 inch bit approximately two to three inches deep, on a slightly upward angle to facilitate better fluid flow. Collection spouts called "spiles" are inserted and tapped lightly into the holes. Spiles may be purchased from some hardware or farm implement stores or may be constructed from hollow sumac or elderberry stems. In some instances where the new tubular hose system is employed, a special plastic tap is used.

Collection containers may be any type of bucket or plastic bag. When open buckets are used, a cover should be improvised to exclude rainwater and debris. We have found that square sheets of plastic secured with large heavy-duty rubber bands around the bucket tops work effectively. Manufactured spiles are designed to hold bucket bails so that the container is hung directly on the spiles. When using sumac or other types of spiles, it may be necessary to drive a nail into the bark to support the bucket.

Collecting the sap will not always be a daily operation inasmuch as sap flow will not occur every day. The flow varies greatly with weather variation and tree differences. Best flow will occur on days that rapidly warm above freezing in the early morning following a below-freezing night. A single tap hole during an excellent flow period may produce one to two gallons per day. Ordinarily, the sap should be collected and boiled down as soon as possible to produce the highest quality syrup because sap allowed to stand, especially in warmer weather, will be affected by bacterial and fungal growth which may produce undesirable flavors. During periods of rather low temperatures, sap may be kept four or five days without drastically reducing syrup quality.

The amount of sap necessary to produce a gallon of syrup will vary depending upon the sugar concentration of the sap. Maple sap at the time of collection is a clear, colorless solution of 1½% to 3% sugar and will not taste anything like maple syrup. Since maple syrup requires a minimum of 65% sugar concentration and sap is approximately 2%, from thirty to forty gallons of sap will be necessary to yield one gallon of the finished product.

The process of producing maple syrup from sap is essentially one of concentrating the solution to a predetermined level through the process of evaporation. The usual procedure is to boil the sap long enough to concentrate the solution and to develop the characteristic maple flavor. It is possible to partially freeze the sap to concentrate most of the sugar in the unfrozen portion because of the lower freezing point of sugar. The concentrate is then boiled down to the desired level. Lightsey (1974) outlines the procedure of this freezing process. In commercial operations, the sap is taken to the "sugar house" where it is boiled in large shallow stainless steel evaporating pans, filtered, and bottled or placed in cans ready for sale.

In our small operation, the sap is boiled in a shallow twenty-quart stainless steel pan on an old wood-burning cookstove located outside in a sunken garden (Fig. 1). The sap is boiled continuously, and as the fluid level drops, new sap is added until we have boiled down ten to twelve gallons. Throughout this process, it is necessary to skim the surface of the hot liquid to remove foam and other materials. When the level drops to a little more than a quart remaining, the boiling syrup is filtered through clean wool or linen cloth into a four-quart saucepan and taken into the house where the boiling continues on the kitchen stove. (If one chooses to boil sap indoors entirely, much care should be taken to ventilate excess steam properly.) When the temperature reaches approximately 219°F or seven degrees above the

Fig. 1. Steve, Roger, and Pete Sutherland boiling down maple sap on the wood-burning stove. Note additional equipment on the table. (Photo by Jack Stubbs, Ann Arbor News)

boiling point of water, the finished product is poured into hot sterilized jars and sealed immediately.

While most of our sap is made into syrup, it could be converted into maple sugar, maple candy, and maple fudge by further concentrating the sap. One of our favorites is "jack wax" which is made by boiling two cups of finished syrup to a temperature of 234°F. (If the syrup foams excessively, the addition of a bit of butter will reduce the surface tension and prevent boiling over.) This very hot syrup is then poured over snow in a bowl and served with a fork to twirl the wax.

Although we usually grade our syrup by taste, smell, and sight, there are very sophisticated methods of evaluating the quality of the finished product. The employment of these methods by chemistry classes can make maple-syrup production a worthwhile educational laboratory exercise (Burt, 1973). A hydrometer may be used to measure the specific gravity of the syrup and by using a table of sugar values, °Brix values, the exact sugar concentration can be determined. Also, chemical tests show that maple syrup is about 63% by weight sucrose, 1% to 2% invert sugar, and approximately 1% various organic acids of which malic acid is most abundant. Variations of these values will produce a product of differing qualities. Toward the end of the season, sap may acquire a "buddy" flavor due to the presence of amino acids in the sap which are produced when buds are rapidly developing. These amino acids can be detected by simple paper chromatography.

While there is a wide range of activities associated with maple sugar production, the techniques are really quite simple and easily learned and once the basic equipment is secured, maple sugaring can be an enjoyable early spring event. In addition to an annual yield of syrup that typically sells for over ten dollars a gallon (1974 price), it has been equally rewarding for us to demonstrate our operation to 4-H, scout, and school groups as well as to many adults who happen by.

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MICHIGAN PLANTS IN PRINT

New Literature Relating to Michigan Botany

A. MAPS, SOILS, GEOLOGY, CLIMATE, GENERAL

Alfred, Stanley D., Adam G. Hyde, & Richard L. Larson. 1974 ["1973"]. Soil Survey of Emmet County, Michigan. U.S. Dep. Agr. 99 pp. + 45 once-folded map plates + 6 folded legends and indexes. [As in other recent soil surveys, includes a general soil map, background information on the county, details on soils, complete aerial photographic coverage of the county with cultural features and boundaries of soil types superimposed in black; in this survey the photography dates from 1965 and the scale is ca. 3″ = 1 mile. Michigan Soil Surveys are now available from the Soil Conservation Service–USDA, 1405 Harrison Rd., East Lansing 48823.]

Alfred, S. D., & A. G. Hyde. 1974. Soil Survey of Charlevoix County, Michigan. U.S. Dep. Agr. 122 pp. + 66 once-folded map plates + 7 folded legends and indexes. [Based on 1965 aerial photography, with scale ca. 4″ = 1 mile. According to the index to map sheets, some of the eastern part of the county represents "Low Intensity Soil Survey," while the rest of the county is "Medium Intensity"; since neither phrase is mentioned in the text, the distinction is not clear. The legend indicates that in the "Low Intensity" survey only broad "Associations" are mapped, but how "Medium Intensity" compares with other soil surveys is not stated.]

Landtiser, Gilbert R. 1974. Soil Survey of St. Clair County, Michigan. U.S. Dep. Agr. 113 pp. + 62 once-folded map plates + 7 folded legends and indexes. [Based on 1970 photography, with scale ca. 3″ = 1 mile.]

Threlkeld, George W., & James E. Feenstra. 1974. Soil Survey of Shiawassee County, Michigan. U.S. Dep. Agr. 113 pp. + 43 once-folded map plates + 6 folded legends and indexes. [Based on 1970 photography, with scale ca. 3″ = 1 mile.]

Weber, Herman L. 1973. Soil Survey of Leelanau County, Michigan. U.S. Dep. Agr. 90 pp. + 39 once-folded map plates + 6 folded legends and indexes. [Based on 1965 photography, with scale ca. 3″ = 1 mile; no mention of the Sleeping Bear National Lakeshore.]

B. BOOKS, BULLETINS, SEPARATE PUBLICATIONS

Bassett, I. John. 1973. The Plantains of Canada. Canada Dep. Agr. Monogr. 7. 47 pp. [Includes dot distribution maps for Canada and adjacent U.S. based on herbarium specimens seen; since no Michigan herbaria were examined, Michigan records are sparsely represented but 4 species of *Plantago* and 1 of *Littorella* are mapped in the state. Includes key, descriptions, cytological and other information.]

Hansen, Henry L., Laurits W. Krefting, & Vilis Kurmis. 1973. The Forest of Isle Royale in Relation to Fire History and Wildlife. Minn. Agr. Exp. Sta. Tech. Bull. 294 (For. Ser. 13). 44 pp. [Includes summary data on acreages of vegetation types, together with data and descriptions for each type; a companion work to the vegetation map by Krefting, Hansen, & Meyer, previously noted here (March 1973).]

Krefting, Laurits W. 1974. The Ecology of the Isle Royale Moose with Special Reference to the Habitat. Minn. Agr. Exp. Sta. Tech. Bull. 297 (For. Ser. 15). 76 pp. [Includes general vegetational information on Isle Royale and considerable data on moose food habits and effects on the vegetation.]

Mullendore, William J., & R. D. Burroughs. n.d. Michigan's Morels and Wildflowers. Mich. Tourist Council & Dep. Nat. Res. [10-page] folder. [A new reprint of two articles from old numbers of Michigan Natural Resources, on "The Morels" and "Protected Wildflowers of Michigan," with colorful illustrations. Available without charge from the Michigan Tourist Council, Suite 102, 300 S. Capitol Ave., Lansing 48926.]

Swink, Floyd. 1974. Plants of the Chicago Region. Ed. 2. Morton Arboretum, Lisle, Illinois. 474 pp. $5.00. [See review on p. 56 of this issue.]

C. JOURNAL ARTICLES

Cummins, Kenneth W. 1974. Structure and function of stream ocosystems. BioScience 24: 631-641. [Based in large part on experimental work in southwestern Michigan; includes SEM photo of oak leaf covered with fungal spores, bacteria, and diatoms after incubation in Augusta Creek.]

Ebinger, John E. 1974. A systematic study of the genus Kalmia (Ericaceae). Rhodora 76: 315-398. [Includes brief information on economic uses, pollination, and poisonous properties, as well as taxonomic treatment with keys, descriptions, and much-abbreviated citations of representative specimens, the latter including a number of Michigan records for *K. polifolia* and *K. angustifolia*; no illustrations or maps.]

Marcks, Brian G. 1974. Preliminary reports on the flora of Wisconsin No. 66. Cyperaceae II–Sedge family II. The genus Cyperus–The umbrella sedges. Trans. Wis. Acad. 62: 261-284. [Includes keys and distribution maps, the latter showing total U.S. range, including Michigan counties, for *C. lupulinus* ssp. *lupulinus* (= *C. filiculmis* auct.), *C. lupulinus* ssp. *macilentus, C. schweinitzii, C. lupulinus* × *schweinitzii,* and *C. houghtonii.* The latter is considered to be a stabilized hybrid. Maps for the other species include a few Michigan counties adjacent to Wisconsin, the records taken from Michigan Flora.]

Rodman, James E. 1974. Systematics and evolution of the genus Cakile (Cruciferae). Contr. Gray Herb. 205: 3-146. [Map shows localities for two varieties of *C. edentula* around the shores of the Great Lakes; representative specimens are cited from Michigan localities (Cheboygan Co. one erroneously said to be "without locality"); possible hybrid cited from Muskegon and Manistee counties; material from Berrien and Allegan counties among that analysed chemically.]

Editorial Notes

We welcome to the Editorial Board Dr. Howard Crum, Curator of Bryophytes and Lichens in the University of Michigan Herbarium and Professor of Botany. He succeeds Dr. Rogers McVaugh, who has served on the Board from the beginning, in 1962.

INDEX NOTICE: No index to Vol. 13 of THE MICHIGAN BOTANIST has been prepared. Cumulative indexes each covering three volumes were issued at the ends of volumes 3, 6, 9, and 12, with the suggestion that each three-volume unit be bound as one. The next cumulative index, covering volumes 13-15, may be expected in the October, 1976, issue.

Plans are being made for the 1975 spring campout of the Michigan Botanical Club, to be held this year at Camp Innisfree in Leelanau Peninsula over Memorial Day weekend.

The October issue (Vol. 13, No. 4) was mailed November 7, 1974.

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*(On the cover: The Pictured Rocks,
east of Miners Castle, Alger County, Michigan.
National Park Service Photo, 1970.)*

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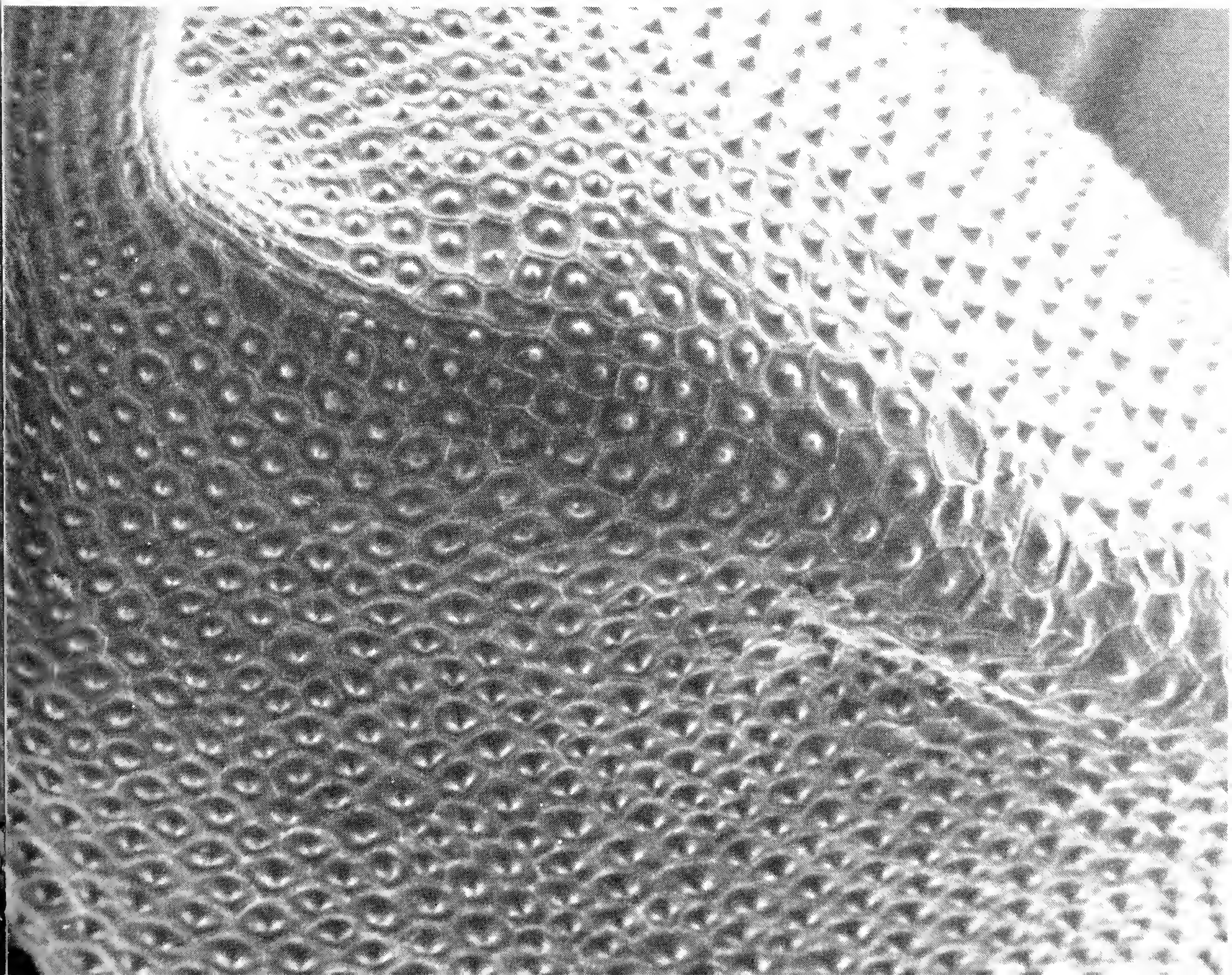
THE MICHIGAN BOTANIST

March, 1975



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A PRELIMINARY STUDY OF THE ACHENE EPIDERMIS OF CERTAIN *CAREX* (CYPERACEAE) USING SCANNING ELECTRON MICROSCOPY

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INTRODUCTION

This study was undertaken to determine the usefulness of Scanning Electron Microscopy (SEM) in resolving a taxonomic problem involving two groups of the genus *Carex* (Cyperaceae). The achenes were chosen because their hard surfaces are ideal for preparation for and observation by SEM. As demonstrated by Schuyler (1971), sedge achenes show a considerable amount of cell diversity—a diversity which provides taxonomically useful information.

On account of its large size, the genus *Carex* has been divided into many sections or groups (see Voss, 1972, p. 246). Pseudo-Cypereae and Vesicariae are two groups represented in Michigan which have been circumscribed in different ways by various workers (see Table I). The groups have been placed near one another on account of their indurated styles and ± inflated perigynia. They have been separated from one another by such characters as slender

TABLE I. Comparison of Classification Schemes of *Carex*.

	Fernald Gray's Manual	Gleason & Cronquist Man. Vasc. Plants	Hermann Genus *Carex* in Mich.	Mackenzie N. Am. Flora	Steyermark Flora of Missouri	Voss Michigan Flora	SEM data
Carex comosa	P	P	P	P	P	P	P
C. hystericina	P	P	P	P	P	P	P
C. lurida	P	V	V	V	P	P	V
C. oligosperma	V	V	V	V	–	V	V
C. pseudo-cyperus	P	P	P	P	–	P	P
C. retrorsa	V	V	V	V	–	V	V
C. rostrata	V	V	V	V	–	V	V
C. schweinitzii	P	V	P	P	P	P	P
C. tuckermanii	V	V	V	V	–	V	V
C. vesicaria	V	V	V	V	V	V	V

(P = Pseudo-Cypereae; V = Vesicariae; – = not treated) scabrous awns on the pistillate scales (in Pseudo-Cypereae) or the number of nerves on the perigynia (6-12 in Vesicariae and 12-25 in Pseudo-Cypereae). However, *Carex schweinitzii* and *C. lurida* are two species which do not fall neatly into one group or the other. Thus, an initial study was undertaken in these two groups to see if SEM could resolve the placement of either *C. schweinitzii* or *C. lurida.*

MATERIALS AND METHODS

The basic techniques as outlined by Schuyler were followed with only slight modifications. The achenes were removed from mature perigynia taken from herbarium sheets and were placed in a vial of water in a L & R Ultrasonic Cleaner in order to break away the outer walls of the epidermal cells, leaving the internal structural detail of these cells exposed for observation. This surface shows a pattern of characteristic bodies or elevated structures which protrude into the epidermal cells. Normally samples were treated for 3-15 minutes, but if the outer walls were not broken away by such treatment the specimens were placed in a vial containing a solution of 9 parts acetic anhydride to 1 part concentrated sulfuric acid and treated in the Ultrasonic Cleaner. After treatment, the achenes were dried and placed on aluminum stubs by means of double-stick Scotch Tape (after Dayanandan, personal communication). The aluminum stubs were then gold-coated for 4½ minutes using a homemade glow-discharge coater (approximately 500 Å of gold deposited). Following coating, the specimens were immediately viewed with a JEOL Model JSM-U3 scanning electron microscope with an accelerating voltage of 15 KV. This procedure of long coating and immediate viewing has eliminated charging problems often encountered with biological material coated for short periods or held several days before viewing. Secondary electron images were recorded with Polaroid Type 55 P/N 4 × 5 film.

SPECIMENS EXAMINED

The following specimens were used for this study. All have been annotated for the Michigan Flora Project, and are in the University of Michigan Herbarium. Collections marked with an asterisk are those from which Figures 1-12 were made.

Carex comosa: Gratiot Co., *Davis, 5 July, 1893; Kalamazoo Co., Hanes 420; Kent Co., Cole, 6 July, 1897; Washtenaw Co., Grassl 8021.

C. hystericina: Charlevoix Co., *Clover 166; Chippewa Co., *Erlanson 735.

C. lurida: St. Clair Co., *Dodge, 3 August, 1904; Van Buren Co., Pennington, 1 July, 1910.

C. oligosperma: Cheboygan Co., Smith 123 & Smith 166; Lake Co., *Voss 14239.

C. pseudo-cyperus: Mackinac Co., *Voss 14365.

C. retrorsa: Mackinac Co., Voss 14327; Schoolcraft Co., *Pringle 383.

C. rostrata: Antrim Co., Bazuin 8930; Chippewa Co., Hermann 7239; Emmet Co., *Ehlers 2611.

C. schweinitzii: Charlevoix Co., Voss 11111; Cheboygan Co., Ehlers 276 & *Ehlers 2388.

C. tuckermanii: Houghton Co., Richards 1282; Mackinac Co., Ehlers, September 1920; St. Clair Co., *Dodge, 28 June, 1904.

C. vesicaria: Calhoun Co., Voss 6553; Keweenaw Co., *Hermann 8145.

RESULTS

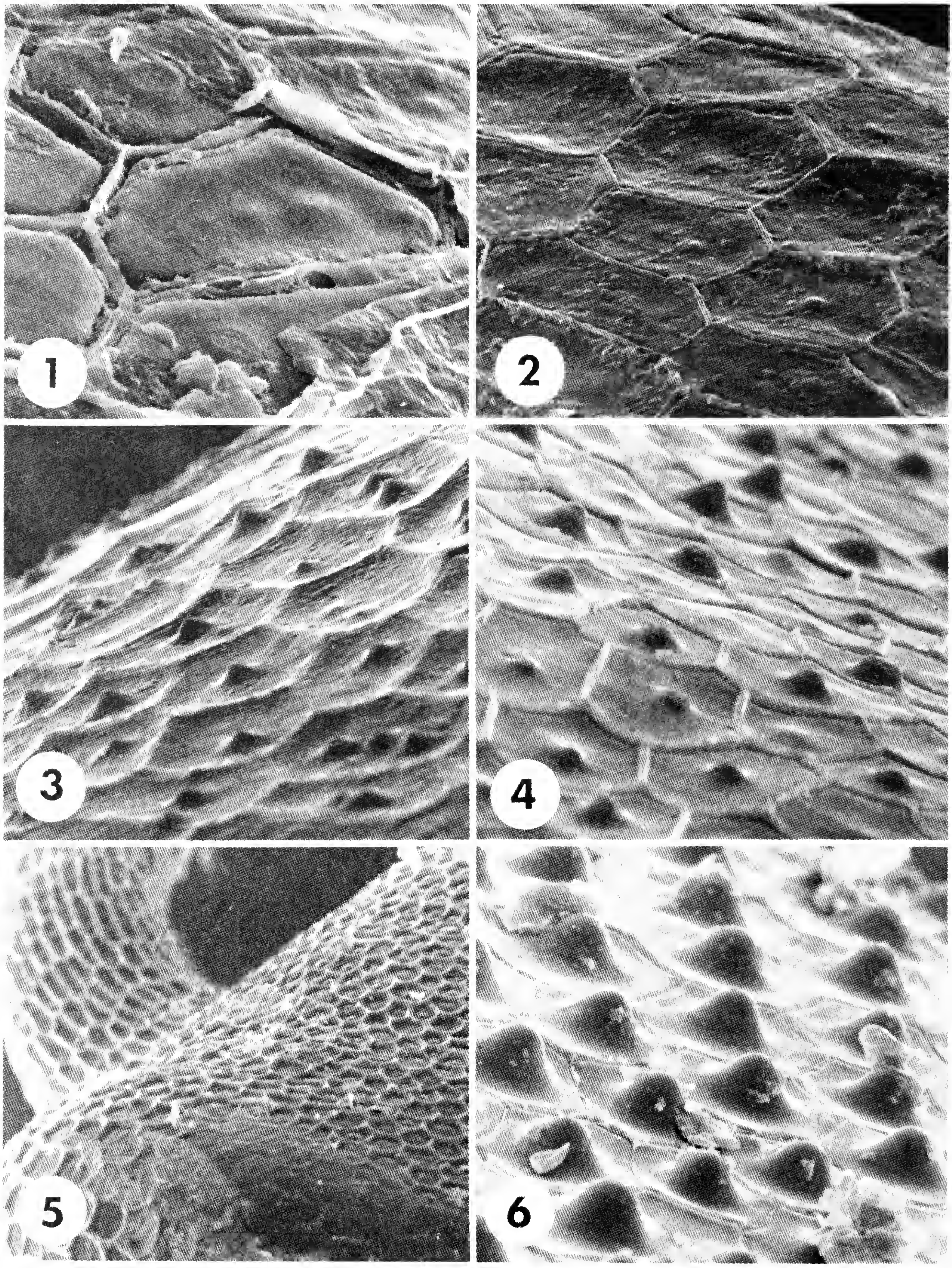
Before discussing specific results, there are some problems involved in this technique which bear mentioning:

1) Removal of the outer wall of the epidermal cells is not always complete with ultrasonic treatment in water. Figure 8 is a low-angle view showing an area where the outer walls have been removed, leaving the bodies distinctly visible; in the foreground these walls are intact, obscuring the shape of the bodies. With the acetic anhydride:sulfuric acid solution, removal of these walls was possible with all species studied.
2) The location on the achene is important in generating useful results, as the spacing and shape of these bodies are somewhat variable over the achene. Therefore, an attempt was made to take all pictures of the bodies on the broad "shoulder" area at the stylar end of the achene (see Fig. 5) so that comparisons would be more useful.

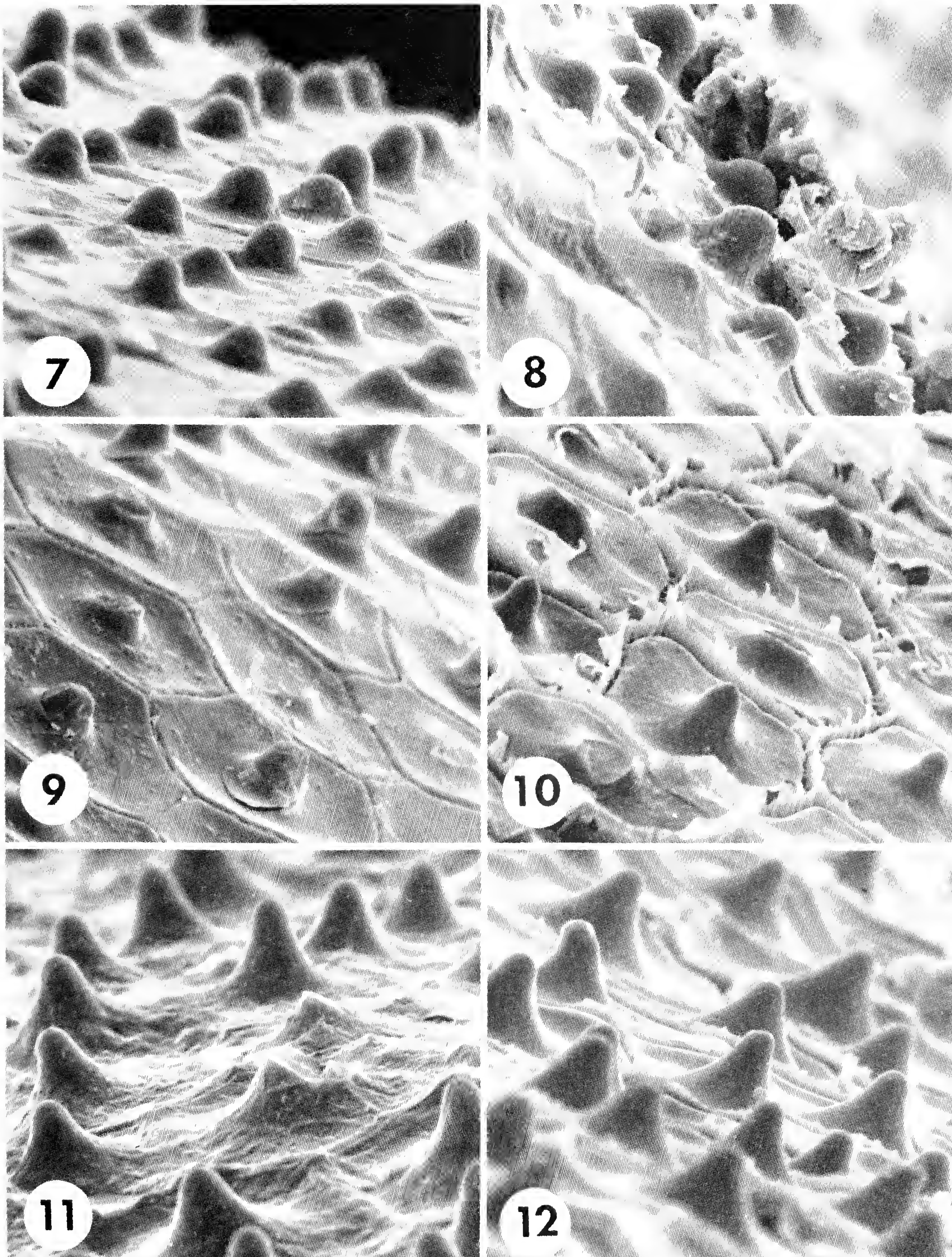
A comparison of the body shape (overall height, height to width ratio, steepness of slope, and pointedness) shows a series ranging from no visible bodies to low, irregularly scattered ones, to taller blunt bodies to tall pointed bodies. This series is outlined in Table II as well as in Figures 1-12.

TABLE II. Preliminary Classification Based on Body Shape. The following series is derived from Figures 1-12. The *C. schweinitzii* end of the series has low bodies or no bodies at all. These bodies become taller and more pointed toward the *C. lurida* end of the series. The division between Pseudo-Cypereae and Vesicariae is based on previous classification schemes, not on any abrupt change in body shape.

PSEUDO-CYPEREAE	*Carex schweinitzii*	no bodies (Fig. 1)
	C. comosa	no bodies (Fig. 2) or few, low, irregularly spaced bodies (Fig. 3)
	C. hystericina	few, low, irregularly spaced bodies (Fig. 4)
	C. pseudo-cyperus	blunt bodies, sloping sides (Fig. 6)
VESICARIAE	*C. oligosperma*	blunt bodies ± parallel sides (Fig. 7)
	C. rostrata	blunt bodies, ± parallel sides (Fig. 8)
	C. vesicaria	pointed bodies, ± parallel sides (Fig. 9)
	C. retrorsa	pointed bodies, ± sloping sides (Fig. 10)
	C. tuckermanii	pointed bodies, ± sloping sides (Fig. 11)
	C. lurida	long, pointed bodies, sloping sides (Fig. 12)



PSEUDO-CYPEREAE: Fig. 1. *C. schweinitzii* (1100×); Fig. 2. *C. comosa* (700×); Fig. 3. *C. comosa* (700×); Fig. 4. *C. hystericina* (700×); Fig. 5. *C. hystericina* (75×); Fig. 6. *C. pseudo-cyperus* (700×).



VESICARIAE; Fig. 7. *C. oligosperma* (700×); Fig. 8. *C. rostrata* (700×); Fig. 9. *C. vesicaria* (700×); Fig. 10. *C. retrorsa* (700×); Fig. 11. *C. tuckermanii* (700×); Fig. 12. *C. lurida* (700×).

CONCLUSIONS

Keeping in mind the problems outlined under Results as well as the problems associated with any system of one-character taxonomy, the SEM photographs reveal several things:

1) *Carex* achene epidermis is well-suited for SEM study; there is variation between species, and this variation may indeed prove taxonomically useful.
2) Ultrasonic cleaning does remove outer walls of the epidermal cells of the genus *Carex,* a genus for which there are no previously published comparative achene studies using SEM.
3) Based on the shape of the bodies, *Carex lurida* seems best to fit in the group Vesicariae since it possesses long pointed bodies very similar in shape to those of *C. tuckermanii,* while *C. schweinitzii* (no bodies visible) best fits in the Pseudo-Cypereae. It is interesting to note two things:
   a) The two taxa in question, *C. schweinitzii* and *C. lurida,* appear at opposite extremes of the series as shown in Table II (one having no bodies and the other having long pointed bodies), yet they are the very taxa which one might have expected to be intermediate, based on the diverse treatments of authors.
   b) The SEM data correlate perfectly with the classification of Mackenzie. The other schemes as listed in Table I (except that of Hermann, who followed Mackenzie) are at variance with the SEM data with respect to one taxon—either *C. schweinitzii* or *C. lurida.*

ACKNOWLEDGMENTS

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NOTES ON THE FLORAL BIOLOGY OF BOX-ELDER (*ACER NEGUNDO*)

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Box-elder (*Acer negundo* L.) is one of the most common trees in southern Michigan, growing in dense stands along streams and floodplains and often appearing almost weed-like around dwellings, in vacant lots, and along roadsides. In some vacant lots we may find hundreds of individuals making practically pure populations. There is some disagreement as to how valuable the box-elder is as a shade or landscaping tree. Otis (1931) wrote that it "accommodates itself to almost any situation. Easily transplanted. Rapid of growth, drought resisting, but short-lived. Much planted for shade and ornament, but it is not a desirable tree for these purposes." The limbs are readily broken, but the plant has a remarkable ability to maintain broken limbs in a living state. I have seen examples in which whole major branches, broken almost completely, their tips lying on the ground and "hanging on by a little bark," are capable of leafing out and flowering in the spring. The female trees of *Acer negundo* are attacked by box-elder bugs, *Leptocoris trivittatus* (Say) in the Corizidae, and these sometimes enter houses in the fall in enormous numbers, to the occupants' dismay (Metcalf et al., 1962). The box-elder has an extensive range (Little, 1971, map 96-N) from coast to coast in North America and from 54°N latitude in Alberta and Saskatchewan down to as far south as Central America, where it grows at 15°N in Guatemala. Numerous varieties have been described, especially to the west and south where the range becomes broken up into small sectors. Botanically box-elder is especially interesting among its immediate relatives in being dioecious, the staminate and pistillate flowers borne on separate trees. All other members of the maple genus, *Acer*, in eastern North America possess bisexual flowers, at least in part. Pollination in *A. negundo* is accomplished by wind.

Wind-pollinated tree species vary in their sexuality. Members of the Walnut family (Juglandaceae), Birch family (Betulaceae), Beech family (Fagaceae), and Elm family (Ulmaceae) are usually monoecious, bearing both female and male flowers on the same tree. In the Willow family (Salicaceae) the plants are dioecious, although we occasionally find abnormal monoecious plants (Wagner, 1968). Some families and genera of trees are "subdioecious," some species dioecious and other species monoecious. For example, the mulberries, *Morus* (Moraceae) may have the sexes separated on different trees or together, even in the same species (e.g., white mulberry, *M. alba*). In ashes, *Fraxinus* (Oleaceae), some species (e.g., *F. nigra*) have the sexes separate or together, others (e.g., *F. quadrangulata*) always together, and still others (e.g., *F. americana*) always separate. The maples are especially diverse in this respect.

In his "Michigan Trees," Otis (1931) illustrated a flower of *A. negundo* which showed both sex organs present. His figure 6 (p. 224) shows a side view of a flower with 3 sepals covering the ovary, 2 stigmas, and a single stamen–in spite of the statement in the text that the flowers are "dioecious." In 1954, in connection with research on variability in the floral anatomy of *A. negundo,* Hall wrote that "In all the literature known to the writer, there is no mention of the occurrence of stamens in female flowers of *A. negundo.*" Hall did, however, notice Otis's interesting illustration.

Hall himself (op. cit.) did find what he referred to as three trees "bearing perfect flowers," and he made anatomical studies of six flowers from them. His specimens, from Cortland, New York, had stamens in some of the pistillate flowers, usually only one or two, but he did find one with three. He concluded that "the usual dioecism of *A. negundo* is not completely established, the species having genes that, under certain conditions, lead to the development of stamens in the pistillate flowers."

In 1912, Fraser described a pistillate tree of box-elder which possessed what he interpreted to be a broken branch bearing bisexual flowers, and he therefore postulated that injury cuased the flowers to develop both sex organs. He called this "induced hermaphrodism" and said that "By some accident the limb in question had been partly split from the trunk, in such a way as to leave about one fifth of its bark and cambium intact." He pointed out that "The condition described is evidently teratological, but since wounding is known in many cases to cause reversion to a more primitive type of structure, it suggests that *Negundo* [which some authors considered to be a separate genus] in its origin has a very close relationship to the genus *Acer*–probably a highly specialized form in this genus."

Herein I shall describe observations made mainly in and around Ann Arbor, Michigan, during 1973 and 1974, including records of different stages of flowering and fruiting and especially the incidence and nature of bisexual flowers.

NORMAL FLOWERING

The normal staminate and pistillate flowers are very distinctive. The male flowers at anthesis have an average of 5 stamens with shallowly curved dark red "banana-shaped" anthers 3-4 mm long. The tip is formed by a conspicuous, sharply pointed extension of the connective. The sepals number mostly five and they are slightly fused at their bases. The sepals are very short, usually around 1 mm long, and approximately half the length of the extended filaments. The female flowers are dominated by the pairs of projecting pale green to yellowish stigmas up to 10 mm long. The base of the flower is laterally somewhat flattened in the plane of the ovary. The primordial samara wings appear as flattened projections on the carpels, their tips approximately equal to the sepal tips. The sepals are much larger than those in the male flowers, reaching between 2 and 3 mm. The sepals on the sides of the samara wings tend to be larger than those between. In outline the sepals are obovate as a rule, somewhat contracted basally, but individual sepals may be lanceolate or even linear. In number there are usually four, but 5-sepaled flowers are frequent. Hall (1954) found that some of the 4-sepaled flowers may have 5 sepal traces, two of which enter one sepal. Both types of flowers are borne in pendent clusters, those of the staminate in dense bundles attached basally, those of the pistillate in more open clusters, the pedicels attached along a short projecting stalk.

The flower buds begin to expand noticeably around the middle to end of March. The opening process is relatively slow, and for a week or so the clustered anthers are visible in the male trees, and the stigmas in the female trees, these still surrounded by the bud scales. Near the end of the second week in April, most of the flowers become extended on long, pendent pedicels (see Fig. 4). At this stage the anthers are dark red, but when pollen discharge occurs, they become black and collapsed. In 1973, most of the pollen discharge occurred during the period 15-25 April, but in 1974 it was an estimated 10 days later. The phenological chart (Fig. 1) is based upon the 1973 records. The staminate trees shed their flowers in clusters shortly after pollen discharge has occurred, and by the first week in May most of the flower clusters have fallen to the ground, although many of them frequently become caught in the branches of the same or adjacent trees. City-grown

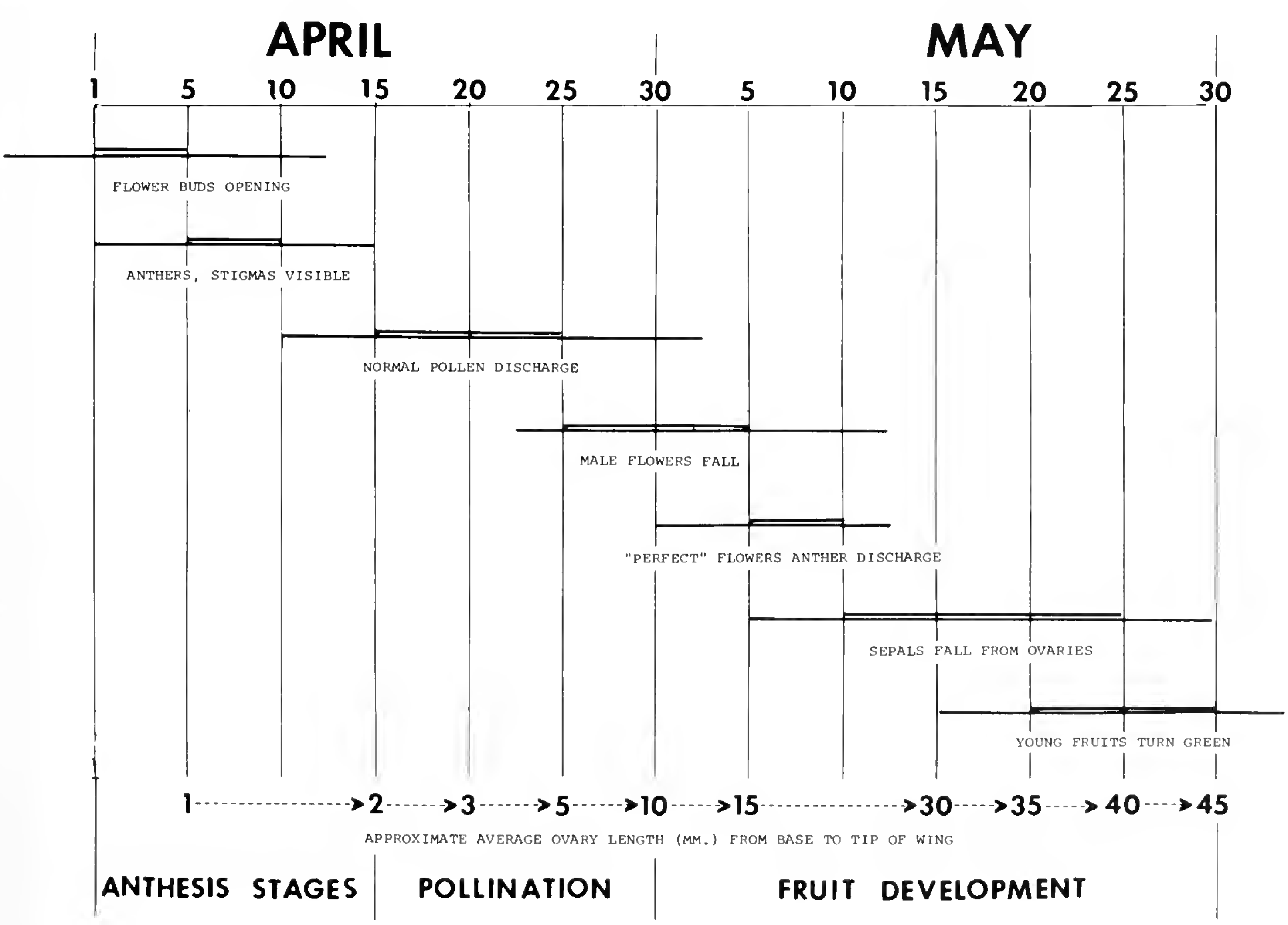

Fig. 1. Phenological chart of flowering stages in box-elder based on observations in 1973 in the vicinity of Ann Arbor, Mich. Double line indicates when most of process occurs; light line, over-all range in time.

staminate trees can create an unsightly rubble of wilted inflorescences on lawns and along curbs at this time.

At approximately the time that the male flowers begin to fall, the ovaries begin to enlarge. By the end of April they have enlarged to as much as 1 cm or more as measured from the base of the ovary to the tip of the wing, and by the end of May they have reached approximately full size, 4.5 cm. One of the interesting features of the development of the ovaries during May is that they assume, for the most part, a brilliant red color. The color is characteristic of each tree: some have deep red wings, others pink, and still others combinations of red and green. By the last week of May most of the fruits have turned green.

The stigmas wilt and fall away. In carpels just over 2 cm long the sepals start becoming more or less "loose," and they are easily knocked off by touching the base of the flower. By the end of May all of the sepals are gone, and the base of the fruit is naked, the remains of the sepals being only ridges or scars.

During the summer the color of the fruit gradually changes from pale green to whitish tan, the condition of the fruit in the winter. In the fall we still see masses of samaras hanging on the trees. Gradually through the winter these may fall, either as single "keys," or as coherent pairs. They accumulate on the ground, and by February some of them have the wing partially or almost completely decayed away. Surprisingly the same type of destruction occurs on the trees on the fruits that remain attached. Apparently the winds knock the dry, crisp samaras together and crack the wings until they break off in part or as a whole, or become skeletonized, showing a network of veins. The retention of fruits during the winter seems to be characteristic of each tree: some still have abundant samaras remaining as late as March, and others have lost all of them, only the fruiting pedicels remaining.

Saplings frequently flower when only 10 feet tall. On 6 May 1973, in a large colony of over 200 small individuals that had seeded into a vacant lot at Milan, Monroe County, Michigan, practically all of the individuals had at least some flower clusters; yet the saplings averaged only 8-10 feet tall. The smallest specimen found with flowers was a staminate plant only 5 feet 9 inches tall.

BISEXUAL FLOWERS

To study bisexual flowers in box elder, I (1) sought female trees in which boughs had been broken and were still alive, and (2) examined undamaged trees. The first approach failed entirely. During the first two weeks of May, 1973, numerous large pistillate trees with broken limbs were observed to see whether flowers produced on them developed the bisexual condition as described by Fraser (1912). In all cases, the flowers on the unbroken branches and those on the broken branches were alike, and none showed stamens. Trees found near Mason, Ingham County, Michigan, on 4 May 1973 were very similar in age and extent of breakage to the one figured

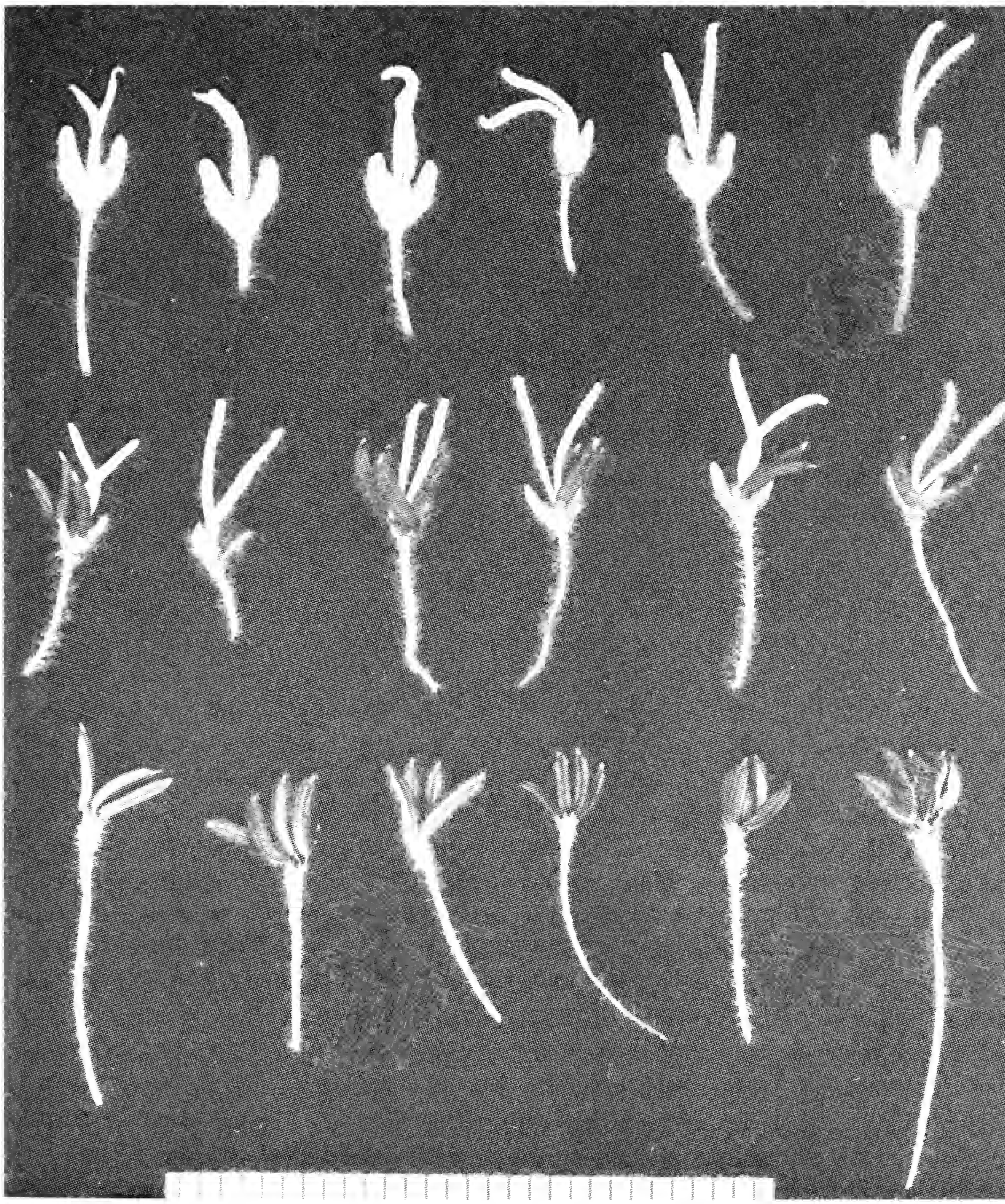

Fig. 2. Flowers of *Acer negundo.* Top: Pistillate. Middle: Bisexual. Bottom: Staminate.

by Fraser. Subsequent searches in the vicinity of Ann Arbor and by Larry West, in the vicinity of Mason, of other trees with living, broken branches were equally unsuccessful.[1]

[1]One question that has arisen in our work is whether the broken branch illustrated by Fraser (1912, fig. 1) might not actually have been from a separate perfect-flowered tree basally grafted to a normal pistillate tree. It will be noted in his photograph that the broken branch arises from a distinct trunk or trunk-branch.

We examined many hundreds of undamaged trees in Washtenaw, Lenawee, Jackson, and Ingham counties, Michigan. In 1973 six small trees were found with bisexual flowers; and in 1974 we found one additional one. No full-sized trees were observed that bore perfect flowers but this may not be significant. The localities for perfect-flowered collections are all in Washtenaw County: (a) Near Huron River along railroad tracks near lower entrance to Nichols Arboretum (*Wagner 73008*, MICH); (b) Vacant lot on north side of I-94, ca. 1 mi. west of Maple Road (*73012*); and vacent lot northwest of junction of Huron Parkway and Glacier Way (*74002*).

As shown in Figure 2, there is considerable variation in the number of stamens in the bisexual flowers. At the Maple Road locality relatively few flowers had both organs present, and those which did usually had only a single stamen. All of the five individuals with perfect flowers showed the same condition—mainly pistillate but with a few flowers having stamens, the stamen number usually one. On the contrary, at the Nichols Arboretum locality, the single plant had a majority of flowers which were bisexual, and the stamen number was mainly between one and four. Only rarely were there five stamens. This is in contrast to normal staminate flowers which vary in stamen number from two to six, having mostly five. Comparisons of stamen numbers are made in Figure 3.

Shortened stamens, in which the anthers are only one-third to two-thirds as long as normal, are occasionally encountered in staminate flowers. They also occur in bisexual flowers and there is an apparent correlation between the average number of stamens per flower and the extent of abortion. The strongly staminiferous flowers of the Nichols Arboretum collection showed approximately one abortive stamen in 20. In contrast, the very weakly

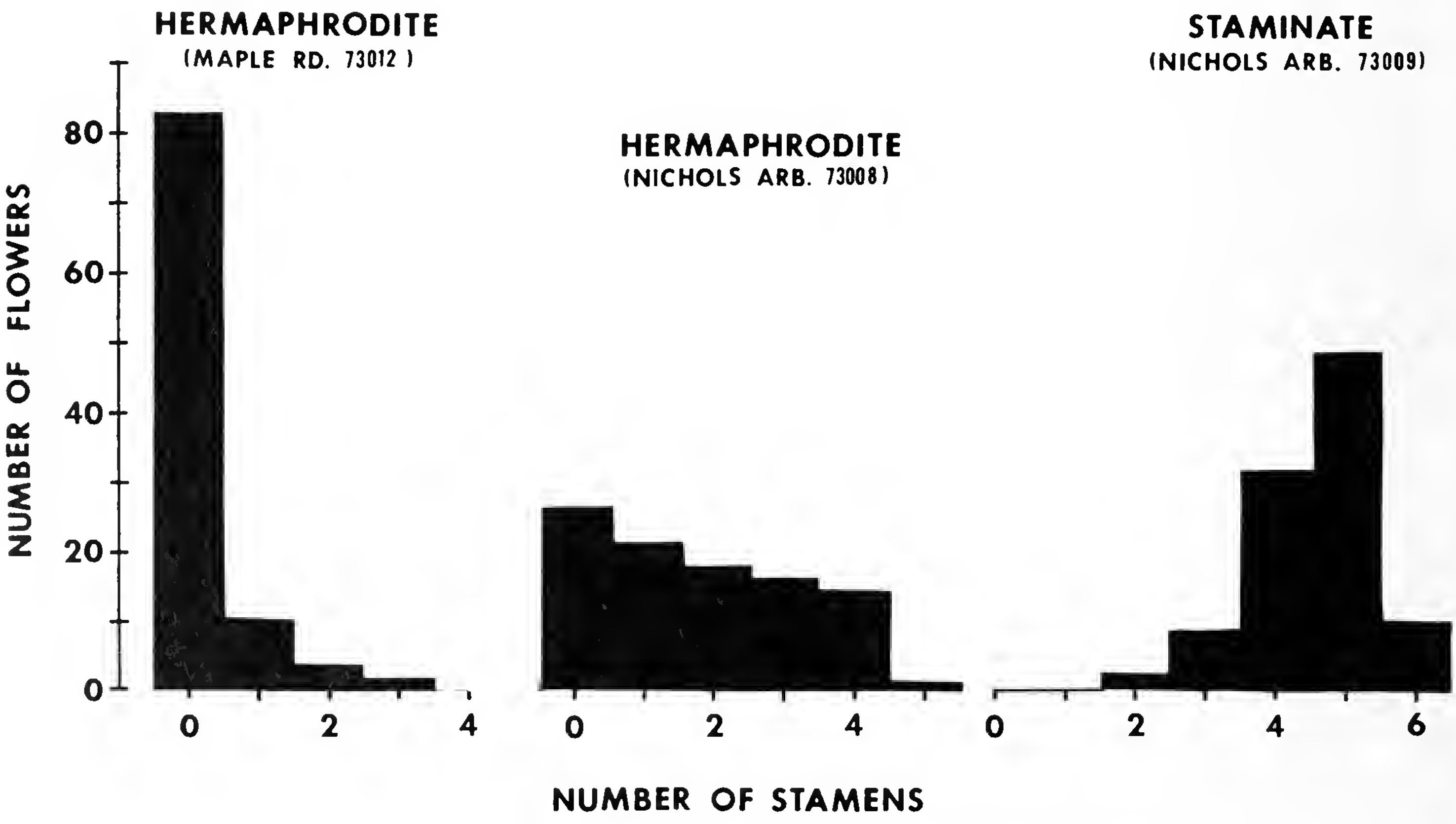

Fig. 3. Stamen numbers. Left: Maple Road, several trees. Middle: Nichols Arboretum, single tree. Right: Nichols Arboretum, several trees.

staminiferous flowers of the Maple Road trees showed approximately one in four.

Pollen samples from various perfect-flowered trees were examined. The pollen is mostly normal, staining in the same way as pollen from ordinary staminate trees. There is some evidence, however, that there is a greater incidence of abortion in the Nichols Arboretum tree than in the others, judging from the presence of numerous small or misshapen grains.

As Fernald (1950, p. 988) points out in his description, the inflorescence structure is different in staminate and pistillate trees, "*the staminate* [flowers] fascicled and *pendulous on filiform pedicels, the pistillate racemose*." I might add that the staminate clusters tend to have more flowers, averaging 10-15 rather than 5-10. Most of the bisexual trees we studied had inflorescences like those of typical pistillate plants, but the Nichols Arboretum individual showed nicely intermediate flower clusters, much "bushier" and more like the staminate inflorescence. This is shown in Figure 4, the perfect-flowered inflorescence illustrated with a pistillate on the left and a staminate on the right. It is interesting to note that the Nichols Arboretum specimen is the one with the large number of stamens present. Also, in winter it can be readily identified among the associated pistillate trees by the form of the infructescence which is shorter and denser, with less development of the main axis. The young infructescence is shown in Figure 5.

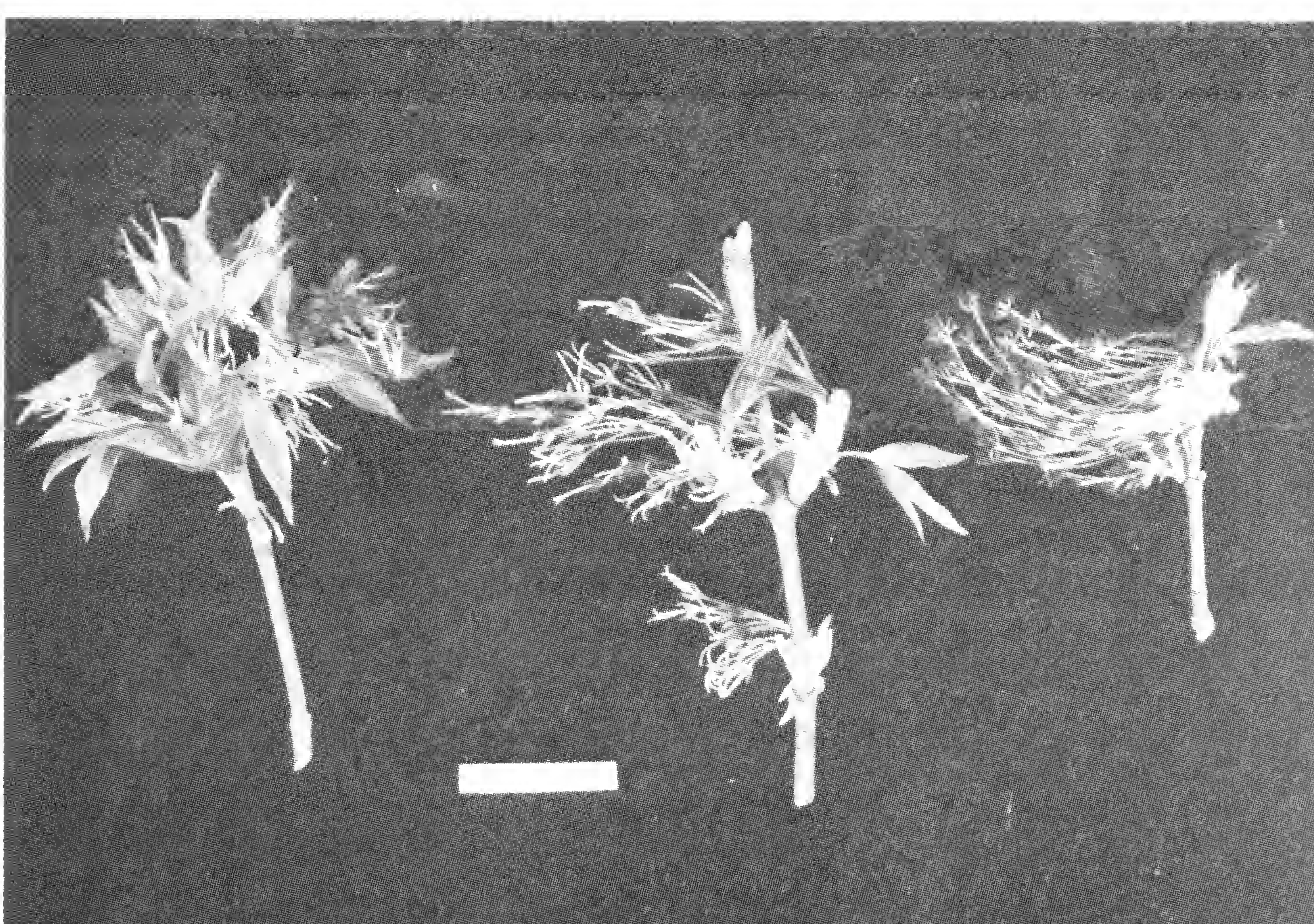

Fig. 4. Inflorescences. Left: From pistillate tree. Middle: From bisexual tree. Right: From staminate tree. All from Nichols Arboretum colony.

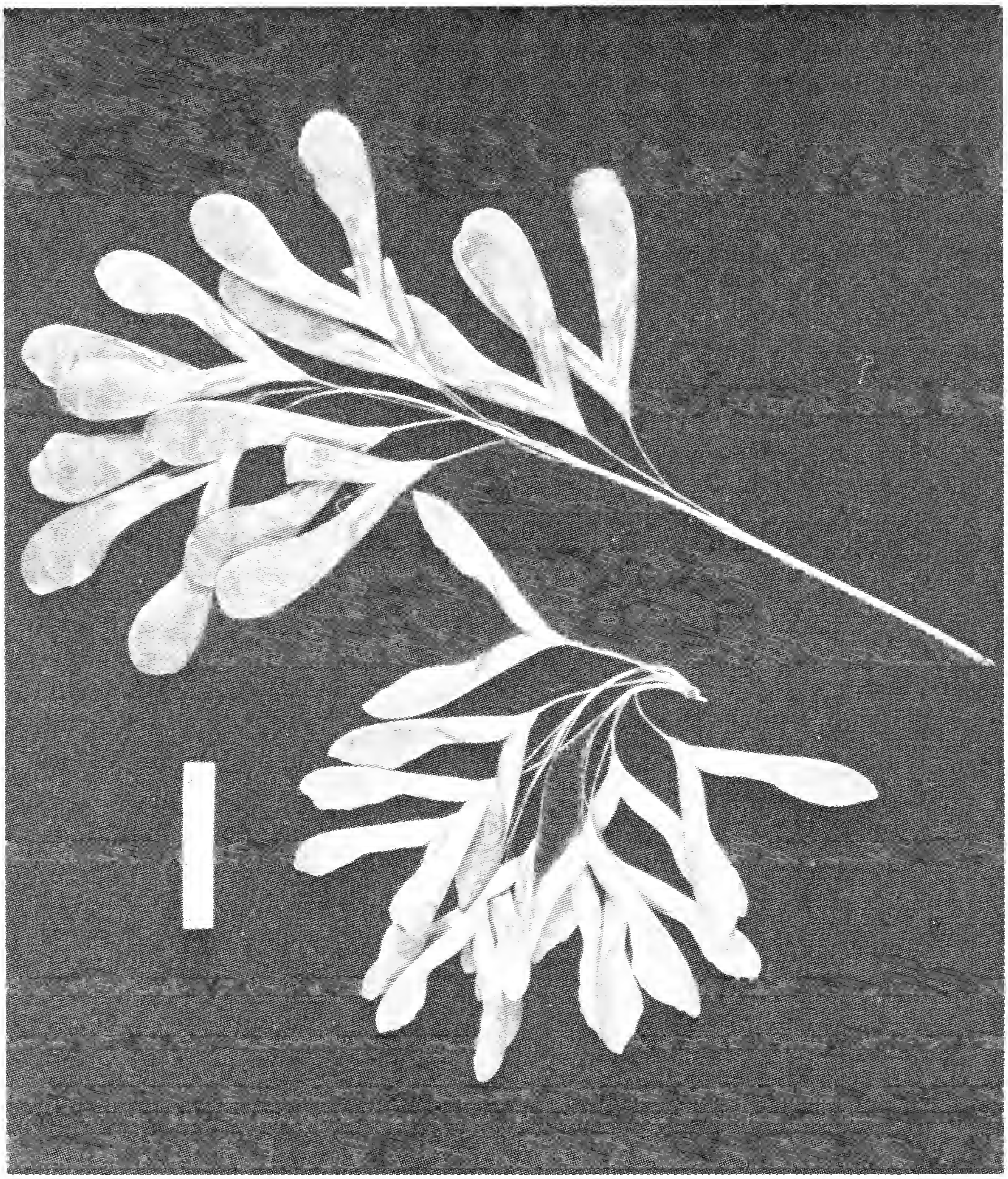

Fig. 5. Infructescences. Top: Typical pistillate specimen. Bottom: Bisexual (Nichols Arboretum tree).

At the same time that phenological stages in the flowering of normal staminate and pistillate trees were observed, the stages in the perfect-flowered individuals were compared. The opening of the buds and the development of the inflorescences are essentially the same in all three types of trees. The differences become evident in the middle of April, when the pollen discharge begins in the normal staminate trees. At the same time, however, the anthers in the perfect-flowered trees remain unopened. Although they can be artifici-

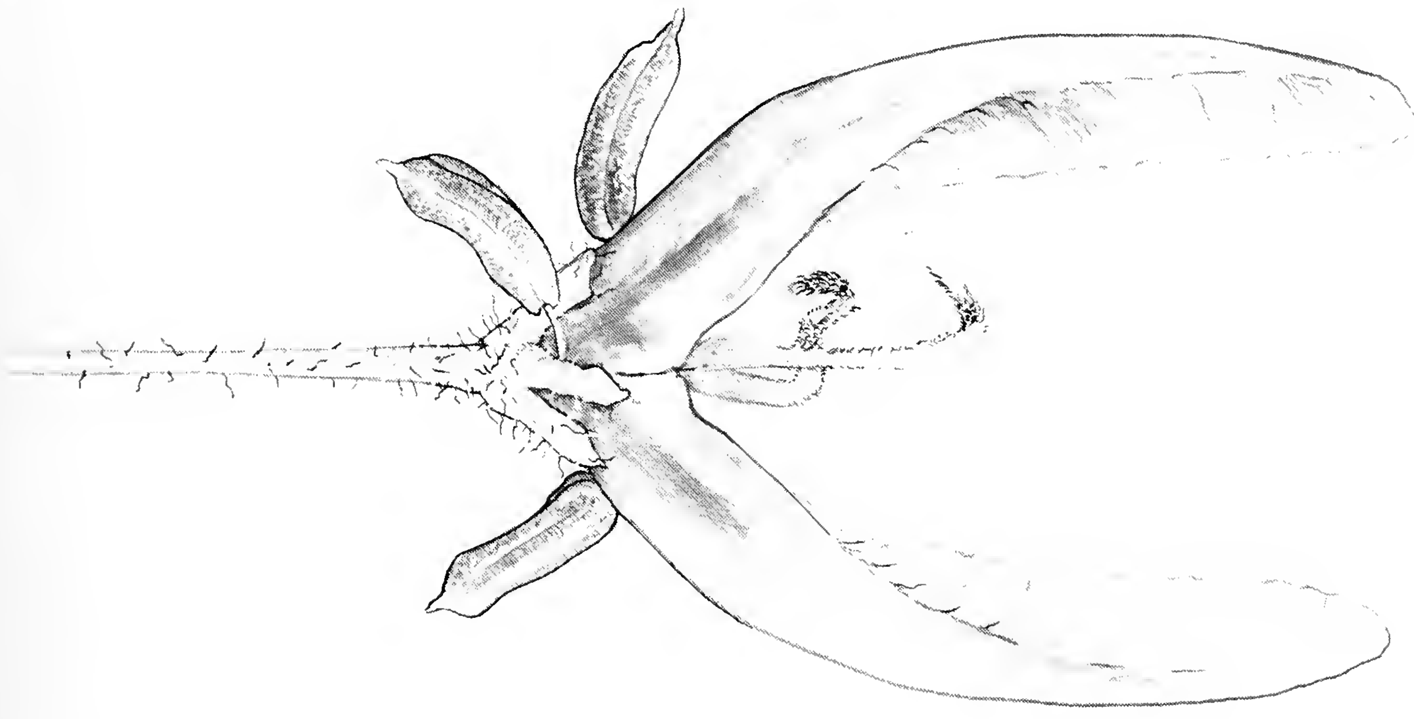

Fig. 6. Perfect flower of *Acer negundo*. (Nichols Arboretum tree). Carpels are just over 1 cm in length, but stamens still remain unopened.

ally opened by drying them in the laboratory, the anthers are mainly undischarged until after the beginning of May. Thus there is a strong timing difference between the opening of anthers of normal staminate flowers and of bisexual flowers. The latter are especially striking during the stages of fruit development when ovaries swollen 1-2 cm long are flanked by still unopened stamens, as shown in Figure 6.

DISCUSSION

Box-elder is characterized by strongly developed dioecism, and bisexual trees are exceedingly rare. Observations in southern Michigan show that flowering begins at the end of March and that pollination must occur mainly around the middle of April, the time of maximum pollen discharge. The ovaries enlarge noticeably in the last half of April and the mature fruit size is reached by the end of May. Why the carpels develop bright red colors during the stages of maturation is not clear, but they become green as they near full size. Bisexual trees found were not evidently damaged or broken individuals, which we had anticipated they would be from an earlier report (Fraser, 1912). All of them appeared to be intact, and all of them (a total of seven individuals) were small trees less than 15 feet tall.

One individual with bisexual flowers proved to be different from the others in inflorescence shape, number of perfect flowers, and number of stamens per flower. With a flower cluster intermediate in form between the typical staminate and the typical pistillate, and with a high number of perfect flowers, these with usually several stamens, this plant is much more equally bisexual than the others studied. In the latter, perfect flowers were extremely uncommon, and usually only one stamen was present, this commonly abortive. We have no evidence at this point that the perfect-flowered condition is caused by environmental factors. The trees showing it are growing side-by-side with normal male and female trees.

Perhaps the most striking observation was that the anthers in perfect flowers tend to remain undischarged well after the period of normal pollen discharge in staminate trees. The stamens do not discharge until after the carpels have reached 1 cm or more in length. This signifies that pollen from perfect flowers has little or no effect on the population because it is prevented by timing factors from fertilization of other trees. Thus the bisexual flowers are functionally pistillate, and this is evidenced by the setting of normal-appearing fruits.

ACKNOWLEDGMENTS

I am indebted to the various students in systematic botany and others who contributed time and effort to this investigation. I wish to thank especially Burton V. Barnes, Larry West, and Ann Sakai for their help and suggestions, and C. E. Wood, Jr., for literature.

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Big Tree Note

The March-April 1974 number of *The Minnesota Volunteer,* the excellent official bimonthly publication of the Minnesota Department of Natural Resources, reports on that state's recent efforts to compile a list of big trees. Forty-four species are listed, for two of which we have no Michigan champion records and two of which ("juneberry" and "willow") are unidentifiable from the common names given. Of the remaining 40 species, only five are larger than the Michigan champions: Black Ash, Cottonwood, Rock Elm, Slippery Elm, and Black Spruce.

PERIODICITY OF SPORE RELEASE IN *MARASMIUS ROTULA*

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INTRODUCTION

Although spore release patterns are known for many important fungal pathogens of higher plants, little is known about them in agarics. Haard and Kramer (1970) and Rockett and Kramer (1974) found most of the agarics and boletes tested to have circadian rhythms of spore discharge, with maxima at night and minima in the daytime. Exceptions were young basidiocarps of *Collybia, Lactarius,* and *Boletus,* which, after being desiccated at an early stage of development, would revive and shed spores immediately after a rain. The property of revival, in the sense of regaining form and shedding spores after rewetting, has been important in the taxonomy of the Tricholomataceae, particularly in the separation of *Marasmius* from *Mycena* and *Collybia.* Since at the time of the present study I was preparing a taxonomic treatment of *Marasmius* in the northeastern and north central United States, I was interested in documenting the extent of revival in at least one species of this genus.

The present study examines spore discharge patterns in *Marasmius rotula* (Scop. ex Fr.) Fr. (wheel Marasmius), a species commonly recognized as having reviving basidiocarps. Parameters affecting spore discharge in other fungi are investigated as they apply to this species. Revival as it occurs in *Marasmius rotula* is compared with that reported for other genera.

METHODS

For this study, a Kramer-Collins spore sampler (Kramer & Pady, 1966) was used between July 16 and August 2, 1971, at the University of Michigan Biological Station. A group of young basidiocarps of *Marasmius rotula* growing on a hardwood log was placed on leaf litter under a thin canopy in an oak woods. Spore discharge was then sampled over a period of 18 days. At the inception of the sampling the basidiocarps were judged to be approximately one week old.

The Model 3 Kramer-Collins 24-hour volumetric sampler operates automatically in the field using power from a 12V DC automobile battery. A spring-wound clock motor activates a vacuum pump four times each hour by means of a 4-lobed cam. Air passes into the sampling chamber through a rotary intake tube placed near enough (1 cm or closer) to the basidiocarps to minimize wind disturbance. The intake tube is narrowed to a slit-like opening through which the spores are drawn by suction onto a slide treated with cellophane tape and silicone grease (Dow-Corning 4). Four times each hour, for a period of ten minutes each time, the vacuum pump draws spores through the opening, and the spores are deposited on the slide. At the end of each hour an automatic mechanism advances the slide 2 mm, and spores are then deposited in a new band. Since the hour of the first deposit is noted each time the slide is changed, the hour during which a particular band was deposited can be identified by the position of the band on the slide.

A Rustrack recorder was used in connection with wet and dry bulb thermistors to record air temperature and relative humidity. Relative humidity was calculated from the readings of the two thermistors and the wet bulb depression. Unfortunately, as it turns out in light of the importance of percipitation later demonstrated for spore discharge in *Marasmius rotula,* there was no provision for accurate determination of the time of onset and duration of rain which occurred during the night. Also, since rainfall had not been an important parameter of spore discharge in previous measurements with the same equipment, no mechanism was available for measuring accurately the trace amounts of rain actually reaching the basidiocarps. Rainfall measurements given were recorded by a single rain gauge about 200 yards from the site of the experiment in an open area and only approximately reflect the amount penetrating the forest canopy. Future measurements of this type should incorporate a number of rain gauges in the immediate area occupied by the basidiocarps.

Spores were mounted for counting in lactophenol-cotton blue. A few other types of spores were encountered on the slides, but those of *Marasmius rotula* could be identified by their small size (6.5-8.5 x 3-3.5 μm) and elliptic shape. Counts were made of all spores within a single field of view under an oil immersion objective from the same relative position on each hourly band, using a Howard eyepiece micrometer disc. The counts cited, therefore, do not represent the total number of spores collected but only a standard sample.

RESULTS

Two large and three smaller episodes of spore discharge correspond with the occurrence of rain. Figures 1-5 show each of these records of spore discharge plotted separately along with relative humidity and precipitation. Note that the scale is different for each period. For period I (Fig. 1) the time of onset of rain is not known precisely but is presumed, on the basis of relative humidity data, to be no later than 10 a.m. According to field notes made at the time, it rained "most of the day." The relative humidity dropped off abruptly beginning about 5 p.m.; this is assumed to be the time that the rain ended. On this assumption, noticeable spore release took place within one to two hours after the beginning of the rain but did not reach a peak until at least two hours after the end of the rain. Within six hours after the peak discharge rate was attained, spore release stopped entirely.

On July 18 the basidiocarps were withered and dry. A light sprinkle occurred at 9:25 p.m., but no release of spores was observed.

During the night of July 19 (Fig. 2) it rained for several hours, probably beginning about 1 a.m. Although negligible numbers of spores (less than

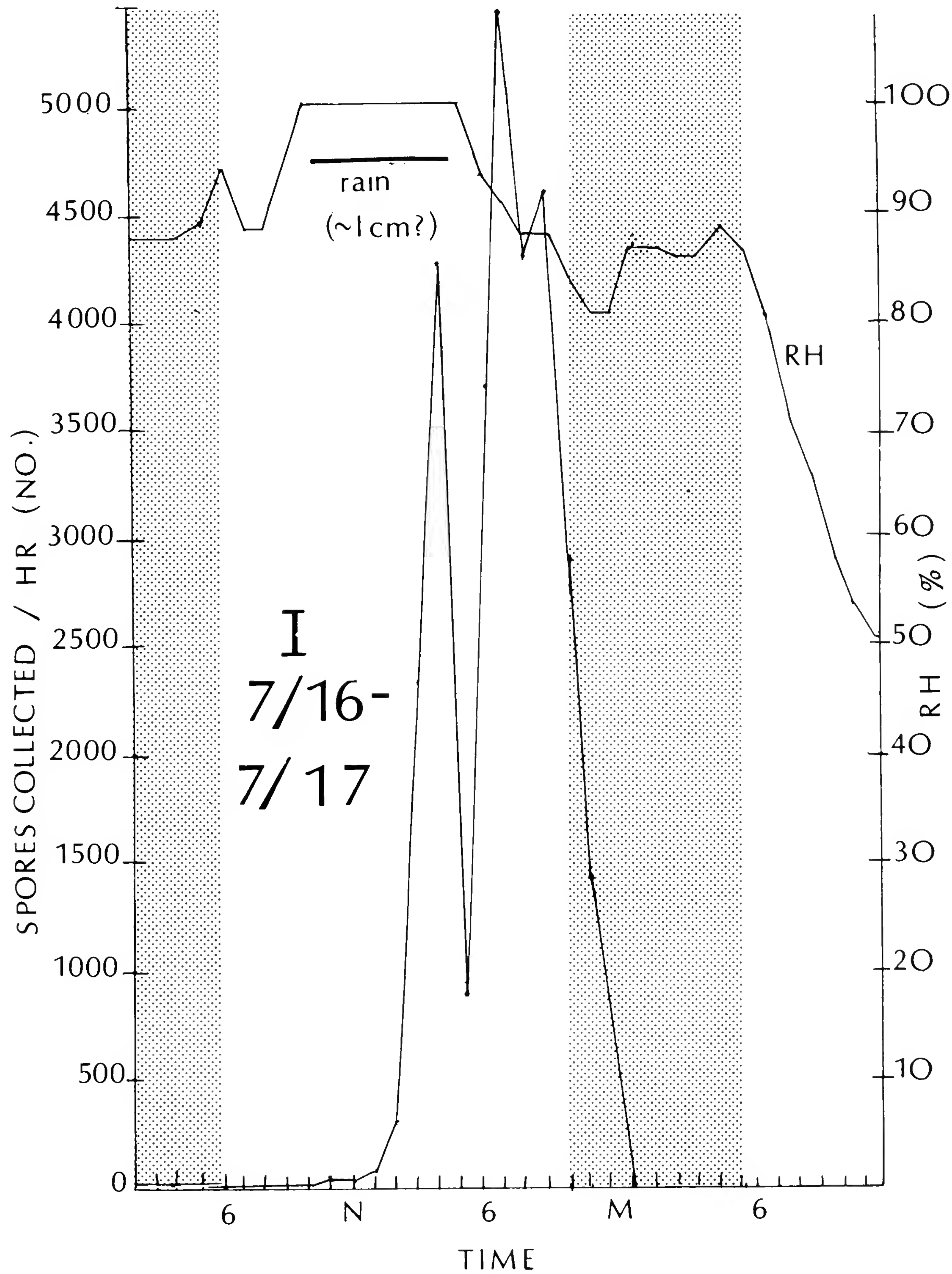

Fig. 1. Rate of spore discharge during Period I. In all figures: approximate duration of rainfall is indicated by a line toward the top of the figure. Stippled areas represent nighttime hours. N = noon; M = midnight; RH = relative humidity.

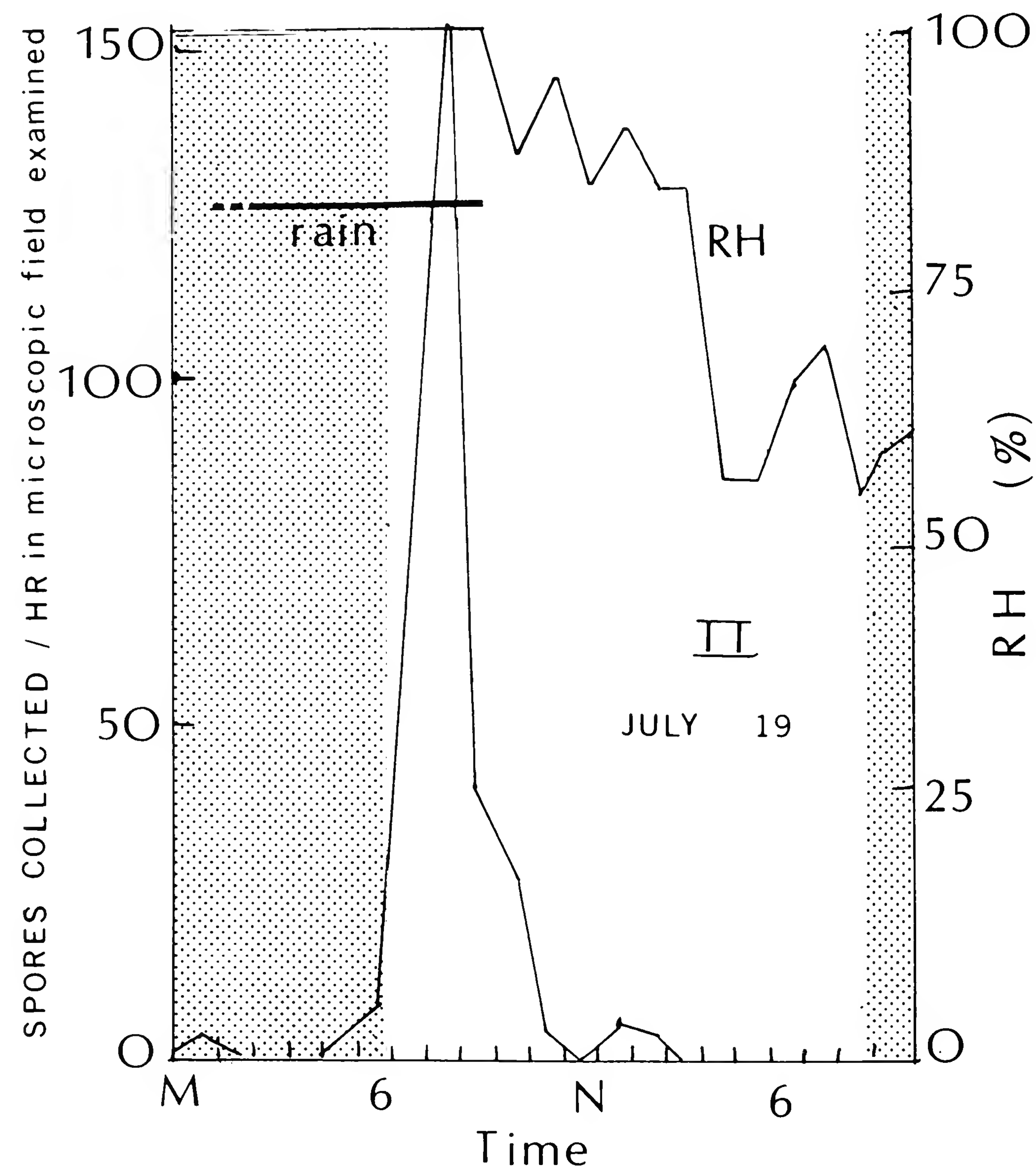

Fig. 2. Rate of spore discharge during Period II.

10/hr) were collected in the sample field of view as early as two to four hours after the onset of rain, significant spore discharge did not take place until approximately six hours after the rain began. The peak of spore discharge was reached an hour afterward, and within four hours spore discharge had virtually ceased.

The longest and heaviest spore discharge was that of July 21-23 (Fig. 3). In this case the actual time of onset of rain (11 p.m.) is known. The total rainfall was 5 cm. Although some spores were discharged almost immediately, seven hours elapsed before a significant increase in spore numbers became apparent. The peak was reached three hours later. This time, instead of falling off abruptly in intensity at the end of the rain, spore release continued at the peak rate for at least 28 hours. Unfortunately., the slide failed to advance on

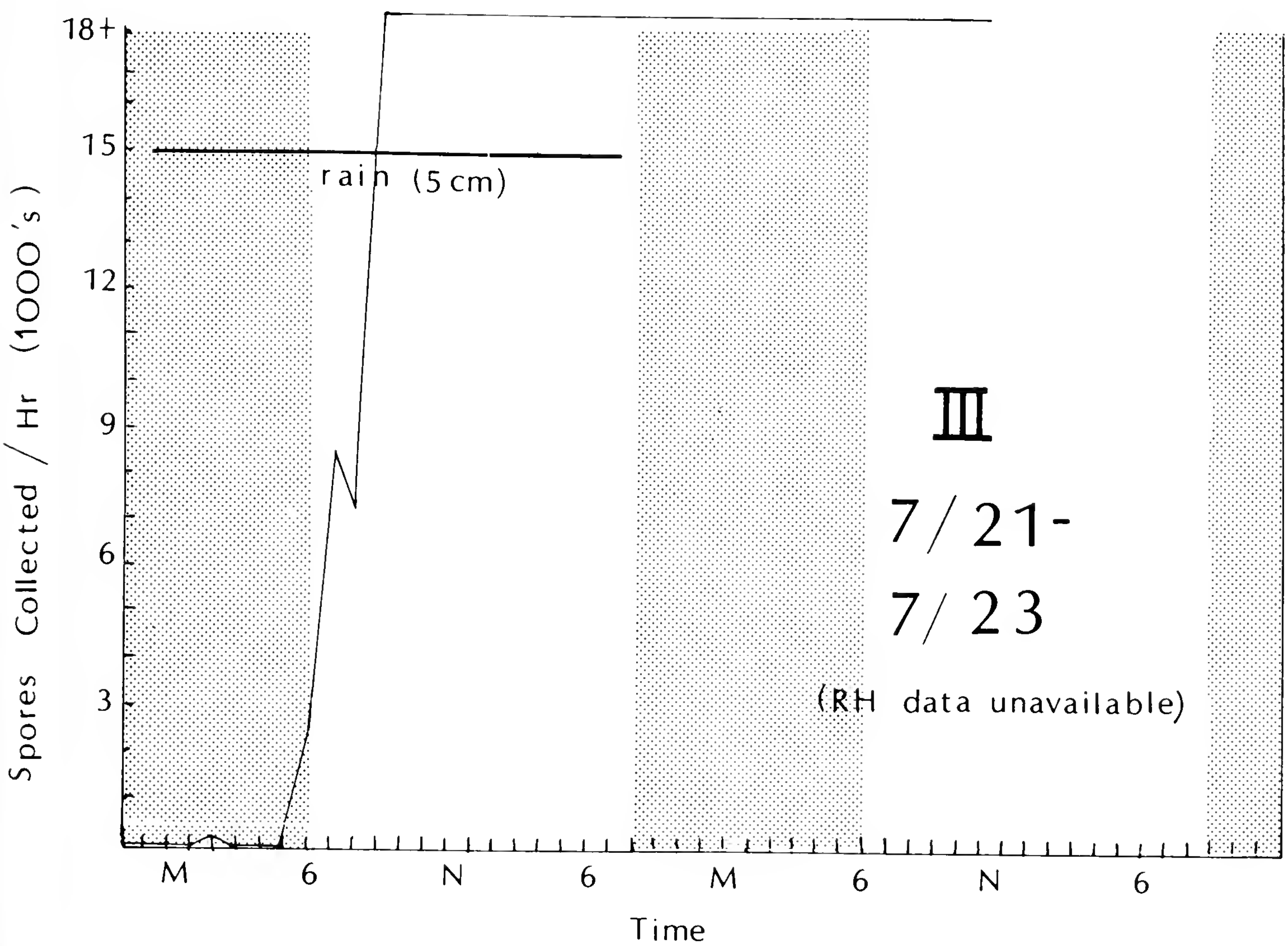

Fig. 3. Rate of spore discharge during Period III. (Shortly before noon on July 23 the slide failed to advance; no data are available for the subsequent period.)

the next sampling day, and no data are available for the period in which spore release was declining. New basidiocarps did not form during this period.

A light rain about 4:15 p.m. on July 26 did not result in spore discharge.

Five days after the end of the heavy rainfall, a light rain fell during the night of July 28 (Fig. 4), beginning about 2 a.m. The initiation of spore discharge came rapidly on this occasion, from one to three hours after the beginning of the rain. A low peak was reached within two hours, and the rate of discharge fell off quickly.

After a dry interval of five days it began to rain at 10 p.m. on August 1 (Fig. 5). By morning 1 cm of rain had fallen. This time seven hours passed before spore discharge became evident, and it took five additional hours to reach the peak of discharge, which was relatively low. Nine hours passed before spore discharge ceased. At this point data collection was terminated.

DISCUSSION

Marasmius rotula demonstrates a pattern of spore release that differs from the circadian rhythm found in many hymenomycetes. In no case during the present study did spore discharge regularly fluctuate between a nighttime maximum and a daytime minimum. Figures 1 through 5 show a direct

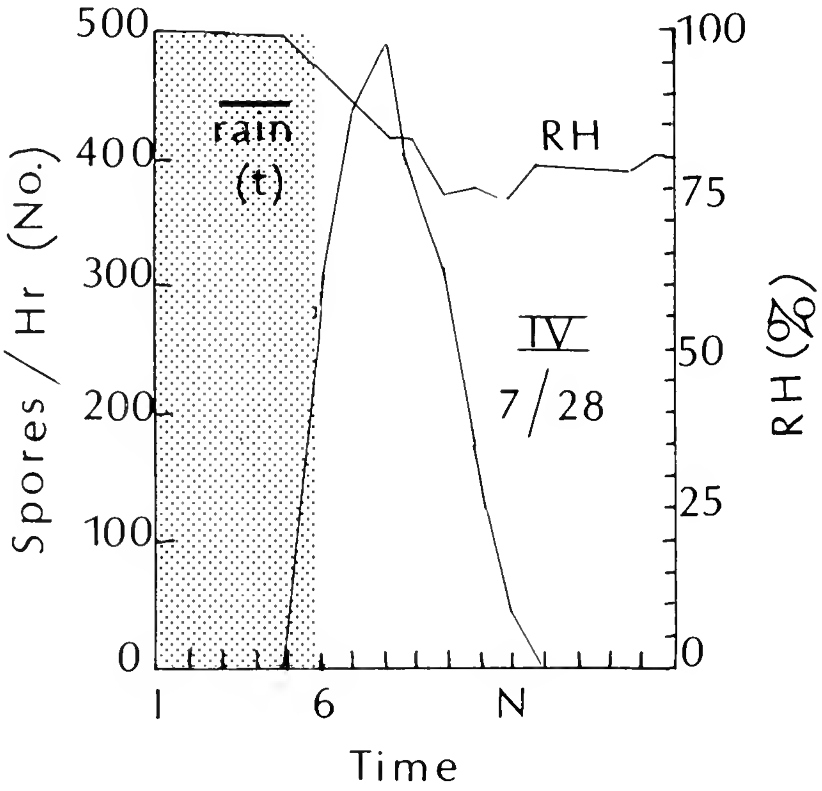

Fig. 4. Rate of spore discharge during Period IV. (t = trace of rain)

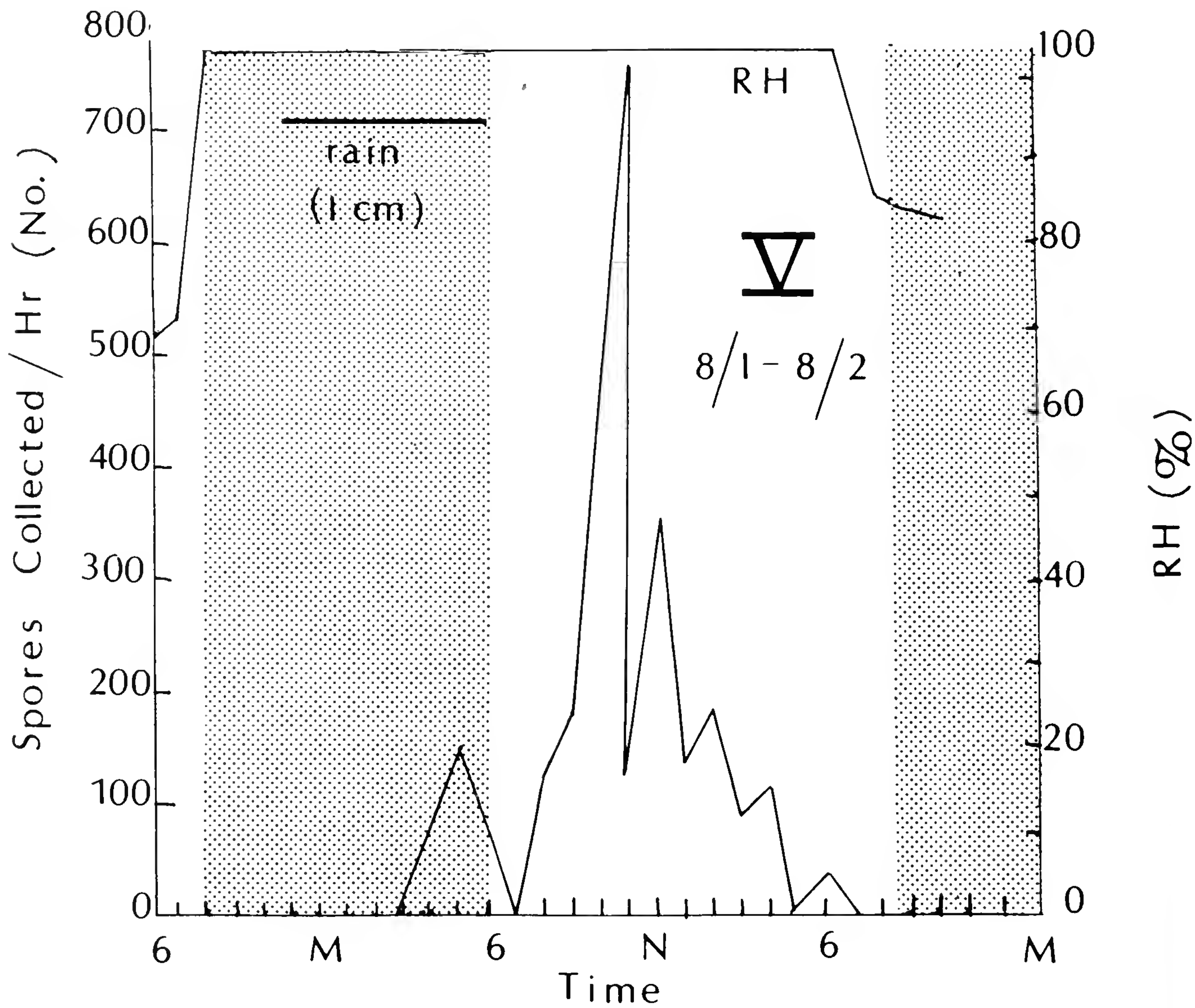

Fig. 5. Rate of spore discharge during Period V.

correspondence, rather, between the onset of rain and the beginning of spore discharge. When it rained in the early evening, spore discharge did reach a maximum at night, but when it rained at 2 a.m., spore discharge did not begin until 6 or 8 a.m. The duration of the peak spore discharge apparently corresponds to the amount of rainfall rather than to its duration, although more precise data about rainfall would be necessary to confirm this. At no time during the study did the relative humidity remain at 100% for more than three or four hours without the simultaneous presence of rain. The present study does not, therefore, rule out the possibility that 100% relative humidity over an extended period, without rain, might result in spore discharge. This is, however, judged unlikely on the basis of field experience. Air temperature, at least during the summer months, appears to have little effect on spore discharge patterns. Doubtless there is a threshold reached in late spring for this species; after the fruiting period begins, other factors become limiting.

A second threshold appears to exist with respect to the amount of rainfall necessary to cause even a weak response. When a light rain fell on July 18 and again on July 26, even though the basidiocarps had recently discharged spores, no response occurred. A slightly heavier rain on July 28, however, was followed by spore discharge. Spore discharge on July 21-23, when 5 cm of rain fell, is proportionately larger than the amount of rainfall might suggest, at least when this period is contrasted with the response on August 1-2, when 1 cm fell. Several factors could be operating. In August the basidiocarps were noticeably aging. Sustained rainfall may allow, in addition, for a period of lamellar growth and basidial development which adds new potential for spore formation rather than simply completing the development of those basidia already present. Such a situation may have been present on July 22 but not on August 2; that is, the basidia were ready to shed spores in the first case but required a period of maturation in the second.

The most noticeable feature about spore release in *Marasmius rotula* as compared wtih other mushrooms (agarics and boletes) tested (Haard & Kramer, 1970; Rockett & Kramer, 1974) is the potential for spore discharge over a period of at least three weeks. Data for other agarics and boletes show periodic or sustained spore discharge over a period of no more than one to six days. Basidiocarps of *Boletus, Lactarius,* and *Collybia* revived only in the sense that, after having been prematurely dried out by conditions of low humidity, they were able to discharge spores when remoistened. Basidiocarps of *Marasmius rotula* can repeatedly revive and shed spores over a much longer period. Rockett and Kramer report a parallel situation in the lignicolous polypores: annual polypores shed large numbers of spores in a single short period, and leathery annual polypores such as *Polyporus versicolor* shed smaller numbers of spores over a much longer period. It would be instructive to test some of the smaller, non-lignicolous species of *Marasmius* to determine which of the two patterns is present.

In summary, spore discharge in *Marasmius rotula* follows not the circadian rhythm found in other agarics tested but a rain-dependent pattern varying in amount and duration with the amount of rainfall.

ACKNOWLEDGMENTS

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Review

THE ALASKA-YUKON WILD FLOWERS GUIDE. Helen A. White and Maxcine Williams, Editors. Alaska Northwest Publishing Co. [Box 4-EEE], Anchorage. 1974. 218 pp. $7.95 [+ .50 postage & handling], paper cover.

This attractive guide to 164 wildflowers and dwarf shrubs illustrates each with a good-sized color photo and a small line drawing. Text consists of stating the height of the plant, its habitat and distribution (especially in Alaska), alternative common or scientific names, and sometimes a brief but vague note on edible or poisonous qualities (e.g., lupine is merely said to be "poisonous" and one familiar with poison-ivy might conclude that it ought not be touched). Many of these plants also occur in the northern Great Lakes region and hence this little book will be of interest in the local area. Statements of distribution are very general beyond Alaska, often as broad as "circumboreal," or misleadingly erroneous as "throughout the northern hemisphere" for *Pinguicula vulgaris* (which in fact rarely occurs south of the 45th parallel). Lake Superior is never mentioned for those Alaskan plants which reach a southern limit on this continent here, such as *Allium schoenoprasum, Cypripedium passerinum, Nymphaea tetragona,* or even *Mertensia paniculata* and *Dryas drummondii,* for which some details of range are given.

There are no keys. Nomenclature and sequence of families follow the monumental "Flora of Alaska and Neighboring Territories" by Eric Hultén, who provided "editorial assistance and review"; it is unfortunate that his name and institution are both misspelled on the title page (in fact, his name is never properly accented). Other errors include misspelling of the epithet *dilatata* for two species, frequent omission of a period after the abbreviation "ssp.," and *Pedicularis* termed a "family." Helpful features include a brief, conservation-oriented discussion of "Wild Flowers in Your Garden" with a list of species which will "usually grow quite well from seed," a glossary which for some reason includes a few specific epithets with their literal meanings, and three indexes to species (by family, common names, and scientific names).

—E.G.V.

STUDIES ON MICHIGAN CHRYSOPHYCEAE. III

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The studies on Michigan phytoplankton are rather extensive, but detailed observations at the species level for the scaled Chrysophyceae are limited. This paper represents observations that have continued since this study of Michigan Chrysophyceae began early in 1971 and is the third of the series (Wujek & Hamilton, 1972, 1973).

METHODS

Collecting methods and locations utilized in this study have been described previously (Wujek & Hamilton, 1972). An askerisk before the name indicates a taxon here first reported for the state.

MALLOMONAS

**Mallomonas heterospina* Lund (Fig. 1)

This species has been reported from a number of localities throughout Europe (Asmund, 1956; Harris, 1970a; Peterfi, 1966) and in Japan (Takahashi, 1959). It has been found during the fall in large numbers in the phytoplankton of Lake Isabella since 1971.

**Mallomonas allantoides* Harris (Fig. 2)

Electron micrographs of the type specimen were first published by Harris (1970b). This species closely resembles, if not in fact is the same as, *Mallomonas pumilo* var. *silvicola* Harris & Bradley (1960). The separation of the two species is based on the presence (*M. allantoides*) or absence (*M. pumilo* var. *silvicola*) of rear spines. Harris (1970b) even mentions that imperfect forms of *M. allantoides* may lack the rear spines. Our specimen was found in Miller's Marsh.

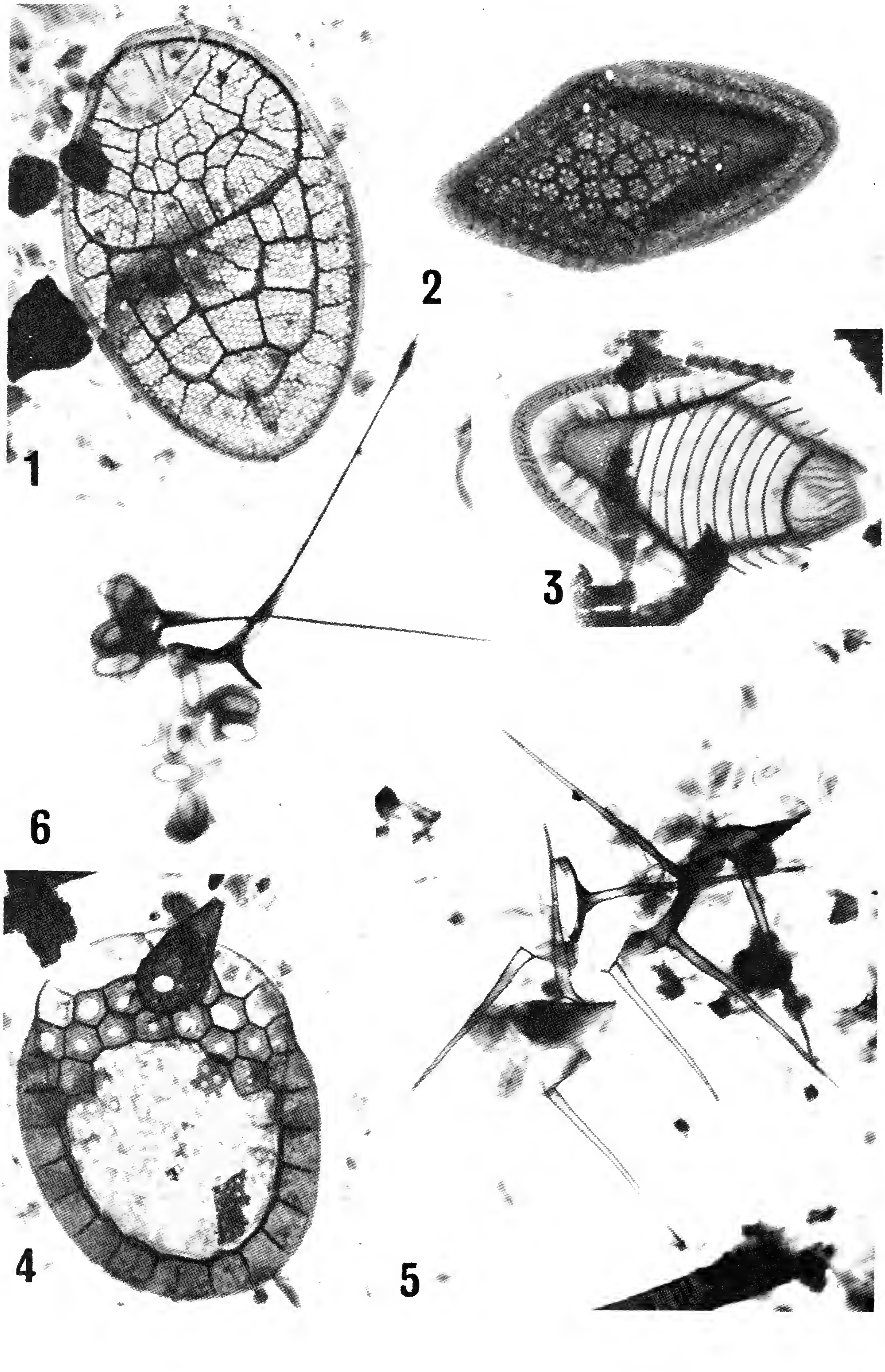
**Mallomonas striata* var. *serrata* Harris & Bradley (Fig. 3)

The scales are of the same ultrastructure as previously reported by Harris & Bradley (1960) and Bradley (1964), but differ slightly in that the dome has more ribbing. Representative scales were found in collections from Lake Geneserath.

SYNURA

Synura uvella Ehrenberg (Fig. 4)

The scales of *S. uvella* are quite distinctive and have been illustrated by many authors (Bradley, 1966; Peterfi, 1966; Takahashi, 1967). Its occurrence in Michigan was reported earlier (Prescott, 1961). Its occurrence in Fox Lake fits well its distribution in other highly colored lakes in other parts of the world.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SPINIFEROMONAS

Spiniferomonas is a recently established genus (Takahashi, 1973) which includes cells that are solitary, free-swimming, biflagellated, and covered with siliceous scales and spines. The genus shows a similarity to *Chrysosphaerella* in the structure of the scales and spines. Six species has been included in the genus, which to date has been observed only in Japan. The two species listed below represent the first report of this genus in North America.

**Spiniferomonas bourrellii* Takahashi (Fig. 5)

The type species, described by Takahashi from material collected in Japan, was observed from plankton tows collected from Lakes Geneserath and Isabella. It has also been observed from Welda, Kansas (Thompson, personal communication).

**Spiniferomonas trioralis* Takahashi (Fig. 6)

The electron micrographs of scales and spines agree with those of Takahashi (1973).. The species was observed from collections taken from Barney's Lake and Lake Geneserath.

SUMMARY

The Chrysophycean species found in samples from a variety of freshwater habitats were identified by electron microscope studies of their scales and spines. All but one of the six species, *Synura uvella,* are new records for the continental United States. In addition, the genus *Spiniferomonas* is reported for the first time since its original description from Japan.

ACKNOWLEDGMENTS

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Figs. 1-5: All figures are ×12,500 unless otherwise indicated. Fig. 1. *Mallomonas heterospina.* Fig. 2. *M. allantoides.* Fig. 3. *M. striata* var. *serrata.* Fig. 4. *Synura uvella.* Fig. 5. *Spiniferomonas bourrellii,* ×3,900. Fig. 6. *Spiniferomonas trioralis,* ×5,500.

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EVIDENCE FOR THE HYBRID ORIGIN OF *POTAMOGETON LONGILIGULATUS* (POTAMOGETONACEAE)

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INTRODUCTION

Aquatic flowering plants for a long time have been known to be phenotypically variable (Sculthorpe, 1967, pp. 218-223). Because of this phenotypic variability, they present some interesting and important systematic problems. This variability may have a genetic or an environmental basis. Cook (1966) has shown by studies of hybridization that the different expressions of the heterophyllous condition in *Ranunculus* subgenus *Batrachium* occur because of genetic differences among the species. By utilizing transplant techniques, Williams (1970) and Mitchell (1969) have shown that variability in *Nymphaea* and in *Polygonum*, respectively, may be brought about by environmental conditions. Ball, Beal, and Flecker (1967) have indicated that the phenolic compounds of *Spirodela polyrhiza* may be altered by the environmental conditions. Also, to add to the difficulties, aquatic flowering plants are often sterile. Hagström (1916) suggested that this sterility may be caused by hybridization. Smith (1967) has shown that hybridization in *Typha* is likely to occur in naturally or artifically disturbed areas.

Regardless of the phenotypic variability, however, botanists have persisted in separating species of aquatic vascular plants on the basis of vegetative differences. Indeed, several taxa of *Potamogeton* have been based exclusively upon vegetative characters. One of these, *P. longiligulatus*, was named by Fernald (1932) from a few specimens collected in the northern United States and eastern Canada. The taxon was said to be distinguished by possessing rigid leaves with 5-9 nerves and a bristle-tipped apex. The species rarely has been found in flower, and only once or twice in partially mature fruit. Several later workers, e.g. Ogden (1957), Voss (1965, 1972), and Haynes (1975), have suggested that the taxon is possibly of hybrid origin between *P. strictifolius* and *P. zosteriformis*. *Potamogeton longiligulatus* is known to occur in several localities in northern Michigan, in each case with one or both of the putative parents. During the summer of 1973 at the University of Michigan Biological Station, we studied two of these populations as thoroughly as possible in order to determine the correct disposition of *P. longiligulatus* in northern Michigan. Both populations examined were in Cheboygan County: bay of the Black River, center sec. 16, T37N, R1W, ca. 3½ mi. SE of Cheboygan; and bay of Cheboygan River, E edge of sec. 18, T37N, R1W, ca. 4 mi. S of Cheboygan. Voucher specimens are in the herbarium of Louisiana State University in Shreveport (LSUS).

MATERIALS AND METHODS

Morphological data were obtained from 20 plants of *Potamogeton strictifolius*, from 21 plants of *P. longiligulatus*, and from 19 plants of *P. zosteriformis*. The characters measured were the vegetative ones utilized by Fernald (1932) to separate the narrow-leaved pondweeds (Table 1). Reproductive characters were not examined since *P. longiligulatus* did not flower during our field studies; both putative parents, however, are reported to have the same chromosome number, 2n = 26 (Bolkhovskikh et al., 1969). The longest leaf on each plant was measured for both length and width. The width of the leaf and the diameter of the stem were taken at their widest points.

Phenolic chemical data were collected from the same 60 plants that were included in the morphological analysis. Leaves and stems of the 60

TABLE 1. Characters used and values assigned to character states in the morphological hybrid index.

Character	Hybrid index value				
	0	1	2	3	4
Leaf length (cm)	3.4-5.2	5.3-7.1	7.2-8.9	9.0-10.7	10.8-12.6
Leaf width (mm)	1.0-1.5	1.6-2.1	2.2-2.7	2.8-3.3	3.4-3.9
Number nerves per leaf	3-8	9-14	15-20	21-26	27-32
Stipule length (cm)	1.3-1.6	1.7-2.0	2.1-2.4	2.5-2.8	2.9-3.2
Stipule width (mm)	1.5-2.4	2.5-3.4	3.5-4.4	4.5-5.4	5.5-6.4
Number nerves per stipule	19-30	31-42	43-54	55-66	67-77
Stem diameter (mm) (parallel to compressed side)	0.7-1.0	1.1-1.4	1.5-1.8	1.9-2.2	2.3-2.8
Stem diameter (mm) (perpendicular to compressed side)	0.2-0.3	0.4-0.5	0.6-0.7	0.8-0.9	

specimens were dried, crushed and extracted in 70% methanol for about 24 hours at room temperature, spotted on Whatman 3MM chromatographic paper, and run in 3:1:1 TBA (t-butanol:glacial acetic acid:water) in the long dimension and in 15% HOAc (glacial acetic acid) in the short dimension. The phenolic compounds were viewed under UV light with and without NH_3 vapor. Identities between spots were made by comparing their size, fluorescence, and R_F values; UV spectra of two spots were determined utilizing the reagents of Mabry, et al. (1970).

RESULTS

The morphological data were analyzed by two methods. First several of the characters were compared diagrammatically by utilizing scatter diagrams as demonstrated by Anderson (1949). Second, a morphological hybrid index value (Anderson, 1949) was assigned to each individual and a hybrid index was subsequently compiled by using the hybrid index value of all 60 individuals. The values assigned to each individual on the basis of the figures in Table 1 were added and plotted on the morphological hybrid index (Fig. 2).

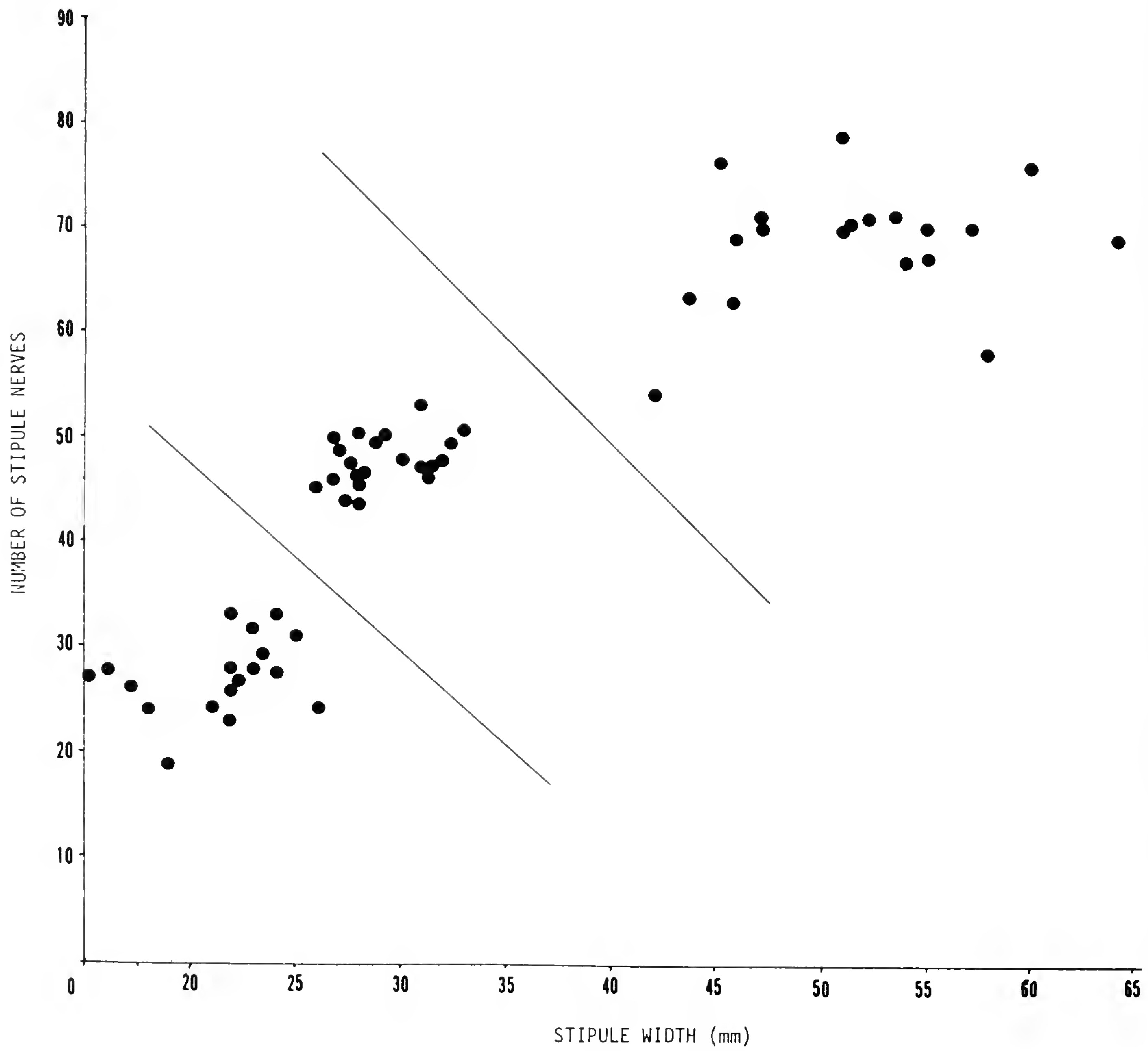


Fig. 1. Scatter diagram for two characters of *Potamogeton longiligulatus*, *P. strictifolius*, and *P. zosteriformis*.

In each scatter diagram, individuals, represented by dots, clustered into three groups. Figure 1 is included as an example of the kind of diagram prepared and is typical of the results. We have utilized the stipule width and stipule nerves as characters since there is no direct relationship between these traits. Each individual represented by a dot in the lower left was one of the original 20 specimens of *Potamogeton strictifolius*, each one in the upper right was one of the original 19 *P. zosteriformis*, and each one in the center was one of the original 21 *P. longiligulatus*.

The characters used, and their manner of calculation, for the morphological hybrid index are given in Table 1. The 60 individuals also segregate into three distinct groups (Fig. 2). The absence of a hybrid index value of 24 is probably due to our sampling technique.

Fourteen different phenolic compounds are present in the three taxa, with 13 of these occurring in either *Potamogeton strictifolius* or *P. zosteriformis*. The resultant chromatographic patterns and intraspecific occurrences of the compounds are illustrated in Figs. 3-8. For these two taxa, all but two of these 13 compounds are species specific—spots 10, 11, 12, 13, for *P. zosteriformis* and 1, 2, 3, 5, 6, 7, 8 for *P. strictifolius*. Two compounds, spots 4 and 9, are found in both *P. strictifolius* and *P. zosteriformis*. Given this situation, one would suppose that hybrids of these two species would possess the additive components (i.e., spots 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13) as in other hybrid situations (e.g. Carter & Brehm, 1969). The profile of *P. longiligulatus* indeed is additive. It contains all compounds 2 through 13 plus a novel one, spot 14. Novel compounds have been found by other workers (e.g. Ornduff et al. 1973; Levy & Levin, 1974) in both natural and artificial hybrids of other plant genera and, presumably, are the result of complementary enzyme systems. The only compound not observed in the chromatographs of *P. longiligulatus* is spot 1. It has the same R_F value as spot 10. Both compounds are deep purple but spot 10 changes to yellow with NH_3 and spot 1 does not. There are two possible explanations for the loss of spot 1. First, spot 10 is much more concentrated than spot 1. Therefore, it is conceivable that spot 1 could be present in *P. longiligulatus* but masked by the more concentrated spot 10. Second, as a result of complementary enzyme systems,

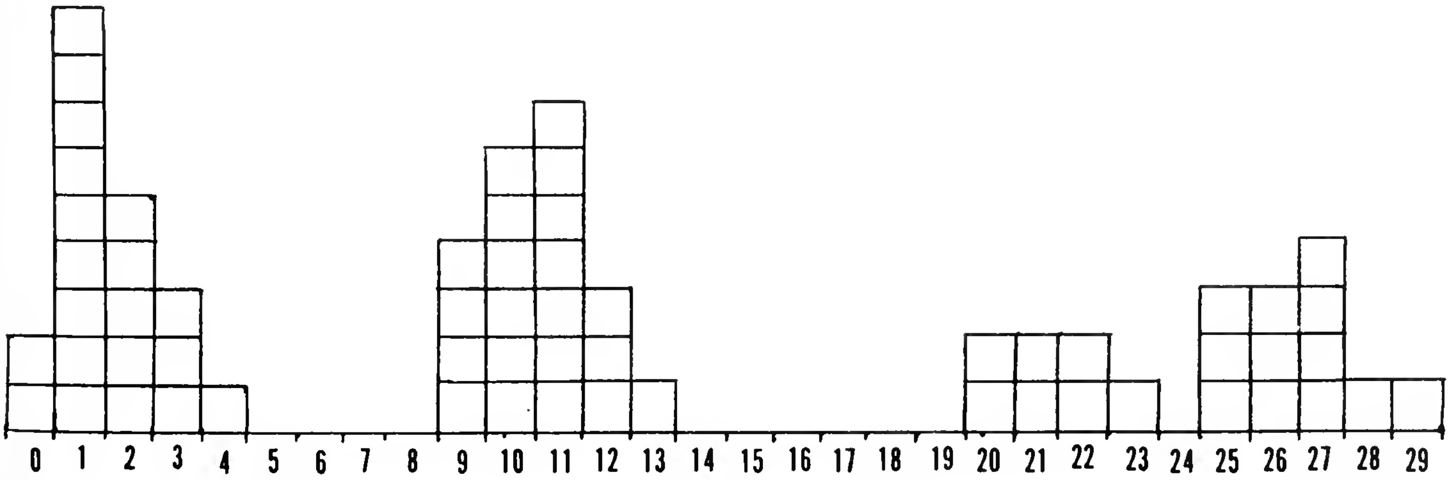
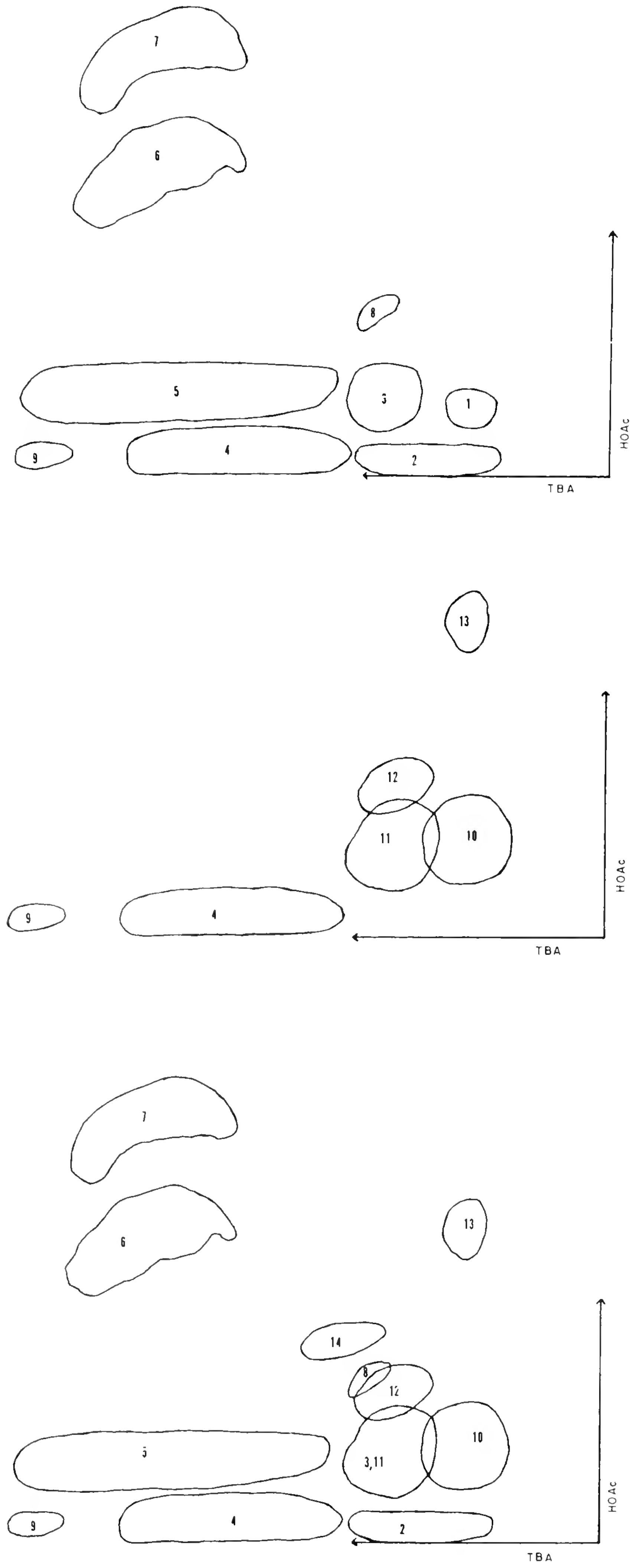


Fig. 2. Morphological hybrid index. Hybrid index values along the horizontal axis and number of individuals along the vertical axis. Each square represents one plant.



Figs. 3-5. Representative chromatograms. Top: *Potamogeton strictifolius*. Center: *P. zosteriformis*. Bottom: *P. longiligulatus*.

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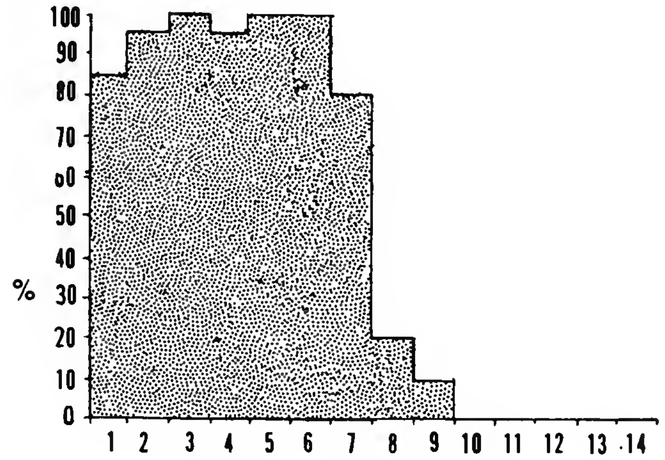

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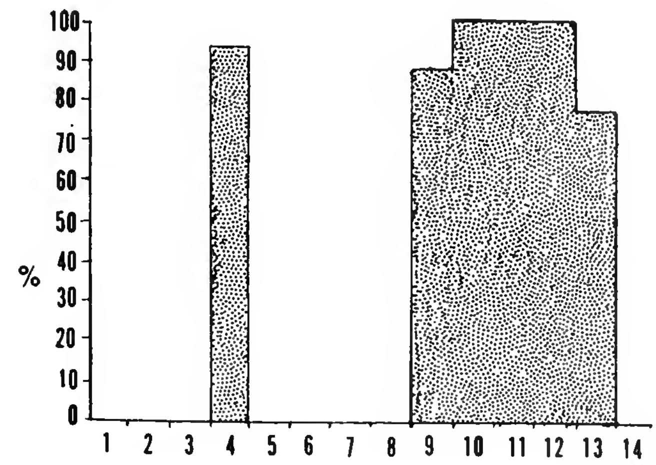

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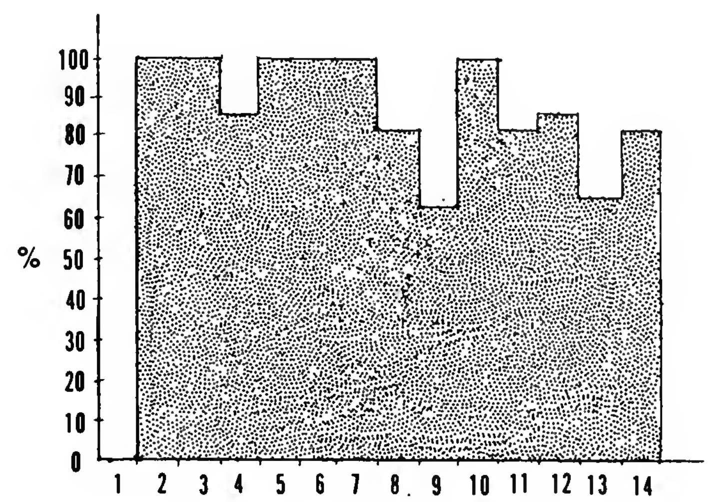

Figs. 6-8. Comparison of the phenolic components of *Potamogeton strictifolius* (6), *P. zosteriformis* (7), and *P. longiligulatus* (8). Percentages indicate the frequency of appearance of the specific spots in all chromatograms run.

spot 1 could have been modified and present in the hybrid as the novel spot 14.

The UV spectra of spots 6 and 10 were determined. Spot 10 is a Luteolin type of compound with a sugar substitution at the seven position. Spot 6 is a Dihydroxyflavone with a sugar substitution also at the seven position.

DISCUSSION

The morphological data illustrate that *Potamogeton longiligulatus* is intermediate in all aspects examined between *P. zosteriformis* and *P. strictifolius.* They could be interpreted as three distinct non-hybridizing species or as two distinct species which hybridize to produce a sterile F_1 offspring. The chemical profile of *P. longiligulatus* is additive of those of *P. strictifolius* and *P. zosteriformis* and thus can be interpreted to confirm the hybrid origin of *P. longiligulatus.* At all the northern Michigan localities for the putative hybrid which we have visited, both of the other species have been present. In fact, in one population, if the collector positions his boat properly, he can have *P. zosteriformis* on his right, *P. strictifolius* to his left, and *P. longiligulatus* under the boat!

The morphological and chemical data together with the field observations indicate that, at least in northern Michigan, *P. longiligulatus* is indeed a hybrid between *P. strictifolius* and *P. zosteriformis*. However, one question remaining unanswered is the mode of origin of the hybrid. The entity could be either 1) sterile hybrids of recent and occasional origin and, thus, not a distinct species; or 2) a distinct species that is reproductively isolated from the parental species and that originated through hybridization at some time in the past. The question is apparently unanswerable until more is known about the reproductive biology of the hybrid.

ACKNOWLEDGMENTS

Field work was conducted during the summer of 1973 at the University of Michigan Biological Station, and laboratory analysis during the winter 1973-74 at the Department of Botany, The Ohio State University. We would like to thank the Biological Station for supporting the field work and Ohio State University for supporting the chemical investigations. Also, we are grateful to Dr. Laurence M. Hardy for critically reading the manuscript.

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Nature education feature --

THE NEVER-ENDING CHANGE IN VEGETATION AND WHAT IT MEANS TO NATURAL AREAS

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Vegetation, the aggregate plant life of an area, is so much a part of our familiar landscape that we tend to forget that it is living, sensitive to environmental changes and injuries, and ever-changing. We take notice of the maturation of sapling trees to form forest stands, and watch fields we knew in the past become overgrown with shrubs and trees, examples of successional change in vegetation. We often fail to take these features into account, however, when selecting, or planning the maintenance of, natural areas. An elementary review of aspects of vegetational change significant to natural areas is the object of this essay.

Vegetation is the massed effect of the intermingled populations of several to many plant species, each of the individual plants interacting with others of its own kind and of different kinds in matters of sunlight, water, and soil nutrients. In recognition of the internal interactions we sometimes call identifiable units of vegetation plant communities or phytocoenoses. The stresses some plant populations exert upon others, by competition we sometimes say, or the simple depletion or accumulation of materials in the soils, cause progressive changes in the relative dominance of different species. Some species get squeezed out; other species may invade from outside areas. Changes in the composition and structure of the vegetation take place in an orderly fashion, in fact, in predictable order within certain limits. This is *plant succession.* Succession may be stimulated by effects of progressive changes in the environment, such as slow recession of the ground water table in the soil. On the other hand, the simple occupation of an exact site by the same plant species for a period often makes the site less suitable for that species, and more suitable for another, different species. By either of these processes, species exchange places, some drop out of the plant community and new ones come in.

Because of the cumulative effects of vegetation on the site, especially the soil and its accumulation of humus, plant succession for a given flora under a given climate proceeds in one direction, as from herbaceous grassland to shrubland to forest. This process of change must end at some point, and it does so by eventually becoming repetitive or cyclic as it approaches most nearly a complete adjustment with the environment, notably the climate and the soil. This state of best adjustment is called *climax* vegetation.

Under the condition of climax, a salient characteristic is that the vegetation perpetuates itself on the site indefinitely, that is until some environmental change (climatic shift, invasion of a plant disease, or whatever) disturbs the equilibrium. However, in this condition the same species does not occupy precisely the same points in space for indefinite periods. An oak tree in a forest, for example, may grow from seedling to mature tree to an old weak tree at 200 or 300 years obviously on the same site; but eventually it will succumb to damage and disease. In its place, in the opening it leaves, other species, light-loving species, move in—starting the successional change back nearer the early forest stage, and developing to the dominance of the species characteristic of climax once more. "Gap phase replacement" is the name given by one plant ecologist to this process. This cycle of replacement of individuals is faster with shorter lived species, of course, and shortest with herbs. Many species of herbs, shrubs, and trees have developed effective methods of vegetative propagation, by stolons, rhizomes, or root suckers, so that they actually persist as individuals for decades or centuries while migrating slowly through the plant community.

A notable characteristic of plant succession is that, no matter whether the pioneer vegetation begins in water, on a wet land site, or a dry site, the site conditions are rendered increasingly mesic, or moderate, especially with respect to water relations, as the climax is approached. Furthermore, although there may be widely different pioneer plant communities, the vegetation of all sites becomes increasingly similar as the climax stage is approached. This is known as the principle of *convergence of succession,* and it is related to the trend toward the mesic condition.

Some sites have one or several environmental characteristics so dominant that succession is limited to some stage before the climax, as with sand dunes or muck swamps. Thus, many persons recognize limited climaxes or climaxes in which the flora is not in complete adjustment with the climate, for example, edaphic climaxes in which the soil is limiting (peat bogs, hardwood swamps), and fire climaxes, in which the high frequency of forest fire is the controlling factor (jack pine open forests).

These concepts constitute rules within which we are required to work in our attempts to select and preserve samples of Michigan vegetation for the future. Let us look at some of the more specific aspects of the plant succession problems with natural areas.

The process by which a climax community maintains itself, by gap phase replacement or something of that nature, obviously requires more than some certain minimum of area for sufficient numbers of individuals and sufficient numbers of cycles at different stages in one time frame. A forest would likely require a greater area to effect replacement than would a grassland. In fact, the grassland situation is made more difficult to predict because of the effects of different annual climates.

Some climax stands are actually less desirable for certain of the natural area objectives than are subclimaxes under control by certain types of disturbance. For example, the Nature Conservancy in England, concerned about saving some of the finest chalk grasslands in the Midlands because of the large numbers of attractive flowering herbs, actually purchased, fenced against grazing, and otherwise protected several parcels of grazing land. Within several years the species with attractive flowers were fewer and sheep fescue was coming in stronger, and after a decade there were almost none of the desired showy plant species on the chalk grasslands. In some instances wildlife cover in the form of open woods and fence rows is assisted in the maintenance of diversity of species and structure by the wildlife itself, as many sportsmen know.

"Old growth," a term often used in ways that imply the climax condition, is not necessarily climax by reason of its age. For example, the venerable stands of white pine at the Hartwick Pines are of relatively great age, but they are not in a situation where they can reproduce on that site; unless the proper intensity of fire goes through those stands, they will probably give way increasingly to mixtures of hardwoods. The question is raised here, and even more pointedly with stands of sandplain jack pines, of whether we should use fire as a management technique to *preserve* representative portions of these "fire subclimax" types. "Smokey the Bear" in some instances stands in the way of good management practice.

We have the general concept that climax vegetation, being an assortment of native species both adapted and sorted out for optimum adjustment to each other and to the climate, is essentially closed with respect to invading species, including "weeds," the aggressive colonizers. Actually, there are species with ecological requirements such that they "fit" into certain places in our climax forest stands. One of these is the Norway maple (*Acer platanoides*), which is becoming an aggressive invader of many kinds of southern Michigan forests, perhaps because its ecological attributes are close to those of sugar maple (*Acer saccharum*) and yet it is still free from diseases and pests which have not followed from Europe. Another damaging invader of our native communities, of all seral or successional stages including climax, is the Japanese honeysuckle (*Lonicera japonica*), which is fast becoming a problem too great for reasonable control.

One more aspect of vegetation management needs to be mentioned here: that of *neglected plantations*. Plantations of forest trees, like all row crops, are vulnerable to explosive infections of diseases and pests. Whenever plantations of conifers, such as those for Christmas trees, are left unthinned or left untended after ice or wind damage, or become overmature, they are liable to become disease and pest breeding grounds. Conifer plantations where stumps have not been treated are becoming infected with *Fomes annosus*, making the sites unsuitable for conifers for a number of decades. The point is that vegetation must be left completely natural in stands of sufficient size to reproduce, or else it must be managed to provide the product we want.

As mentioned above, plant succession is generated by change, either from within the plant community by its own alterations of site conditions, or from without by other changes in environmental conditions. Two of these latter changes are of concern in maintaining stands of vegetation in "original" condition. One is the general lowering of the ground water table in settled areas. In urban areas the ground water level has receded at least 5 to 10 m, and in most places several times that depth. The change in farming landscapes has been less but nevertheless general. The effect is noticeable on all vegetation, but strongest on swamps, bogs, and marshes, many of which have disappeared through the succession generated by the drop of the ground water table. This is one reason why special efforts must be made to preserve as much as possible of the remaining wetlands carrying natural vegetation.

The other pervasive change, shift in climate, is generally outside our means of modification as regards vegetation. However, the current outlook is that the Northern Hemisphere temperate latitudes have entered on the gradual progression to another major glacial interval. Of course, the actual advent of glacial climates could be no sooner than several thousand years from now, and there will be shorter periods of warmer and cooler climate to diversify the record of a general cooling trend. However, in selecting sites for the preservation of given communities and selected species, it would be well to keep in mind the microclimatic features of the site (exposure, ground water, etc.) which might reinforce, or hopefully cancel out, adverse low temperature conditions.

In the selection and management of natural areas and their vegetation, the fact and principles of persistent successional change must be kept constantly in mind. Man is a primary cause of change generating plant succession, but other factors continue to operate as well, and all these need to be considered for their effects on natural areas in question.

Review

WINTER KEYS TO WOODY PLANTS OF MAINE. By Christopher S. Campbell and Fay Hyland. Univ. Maine Press, Orono. 1975. 52 pp. + 53 pl. $3.00, paper cover.

This book features remarkably clear and lifelike drawings by Mary L. F. Campbell, usually larger than natural size and showing leaves and fruits persistent into winter, twigs, and buds. The text consists of keys to the native and established woody plants, generously defined to include not only *Gaultheria* and *Linnaea* but even *Aralia nudicaulis, Chimaphila,* and *Potentilla tridentata.* The keys are excellent, thoroughly parallel in construction, with all characters mentioned in one lead of a couplet contrasted in the alternative. Of course there are problems provided by Nature (e.g., couplets 27 and 29 in the key to species of *Salix*). There is a very good glossary, mostly with crisp, concise definitions. The index is thorough, with page and plate references following scientific names and full cross-referencing from common names, indexed by both noun and adjective portions. Typographical errors are apparently few. Gray's Manual is followed for nomenclature. The volume is dedicated, with a brief biography, to a Maine native, the late M. L. Fernald. It should prove very useful in the northern Great Lakes region where the woody flora is nearly identical (about the only locally significant omissions in the Maine manual are *Prunus pumila* [sens. str.], *Salix serissima,* and the admittedly local *Ceanothus douglasii, Hypericum kalmianum,* and *Rubus parviflorus*). In southern Michigan and neighboring areas, the absence of more southern species will be felt (e.g., *Aesculus, Asimina, Celtis* spp., *Cercis, Euonymus* spp., *Juglans nigra, Ptelea, Quercus prinoides*).

—E.G.V.

AKEBIA QUINATA ESTABLISHED IN MICHIGAN

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Akebia quinata Dcne. (Lardizabalaceae) is an ornamental, twining vine native in eastern Asia and which has been introduced into this country as a garden and greenhouse species.

I have found a spontaneous occurrence of *Akebia quinata* for the first time in Michigan near the Broadway Street bridge at the north side of Ann Arbor, Washtenaw County. The site is located within the city limits on a canal bank adjacent to the Huron River. The soil here is well drained and slightly basic. The colony is thriving and outcompeting native species as well as other introduced ones, forming a dense ground cover starting at the top of the canal and extending onto the floodplain. *Akebia quinata* has succeeded in replacing all other ground cover in an extensive area of ca. 30 x 50 feet. Climbing up on living mid-story trees, the colony has apparently killed several shrubs and threatens several trees by shading them (Fig. 1).

So that others may be on the lookout for this species in this area, I briefly describe it as follows: The twining stem is glabrous and greenish. The leaves are alternate and palmately compound with usually five obovate retuse leaflets attached to a long petiole which is articulated near the base. Inflorescences are borne in the leaf axils. The flowers are pedicellate, aposepalous, and 3-merous. Sepals are petaloid and purplish. Flowering time in this locality was mid-May.

Associates in the overstory include *Acer negundo, Ailanthus altissima, Fraxinus americana, Morus alba, Populus deltoides, Ulmus americana*; and on the floodplain, *Salix nigra.* Associates in the understory include the following: *Cornus racemosa, Lonicera tatarica, Parthenocissus quinquefolia, Rhus typhina, Rosa* sp., *Rubus* sp., *Symphoricarpos orbiculatus,* and *Vitis riparia.* Herbaceous species include *Daucus carota, Hesperis matronalis, Impatiens biflora, Solidago* sp., *Polygonum scandens, Urtica dioica,* and various grasses.

The general forest type here is a lowland composed mostly of dead elms killed by the Dutch elm disease. The elms have been succeeded by city weed species such as *Ailanthus* and *Morus.* Other introduced species have invaded the shrub layer with *Lonicera* dominating.

In this country *Akebia quinata* is a species that is grown on garden walls or in greenhouses to cover pillars. Ernst (1964) writes that "The fruits and roots sometimes are used medicinally in China. . . ." Others describe this plant as having a use for botanical teaching: "Because the species can be widely grown in temperate regions and produces relatively large, readily dissected carpels it should be of considerable value as a source of material for teaching and research activities involving primitive angiosperms" (Payne & Seago, 1968).

Apparently the first noted escape of *Akebia quinata* was at Sandwich, Massachusetts, where Fernald collected it in 1922 (Fogg, 1930). Fogg (1930) reported knowing it since 1923 near Woods Hole, Massachusetts, where it was climbing over a stone bridge. Another escape has been described from Madison County, North Carolina, where it is doing quite well and is apparently free from insects and diseases (Ahles & Radford, 1959). Fernald (1950) states that in the northeastern United States this species "tends to spread from cult."

I was unable to find mature fruits. Perhaps conditions at this location are unsuitable for their formation. However, should fertile fruit be produced by this population, then, as several past authors have warned, *Akebia quinata* could become a pest of our forests just as it has apparently shown itself to be in Madison County, North Carolina.

Voucher specimens will be deposited in the herbaria of the University of Michigan and Michigan State University.

LITERATURE CITED

Ahles, H. E., & A. E. Radford. 1959. Species new to the flora of North Carolina. Jour. Elisha Mitchell Sci. Soc. 75: 140-147.

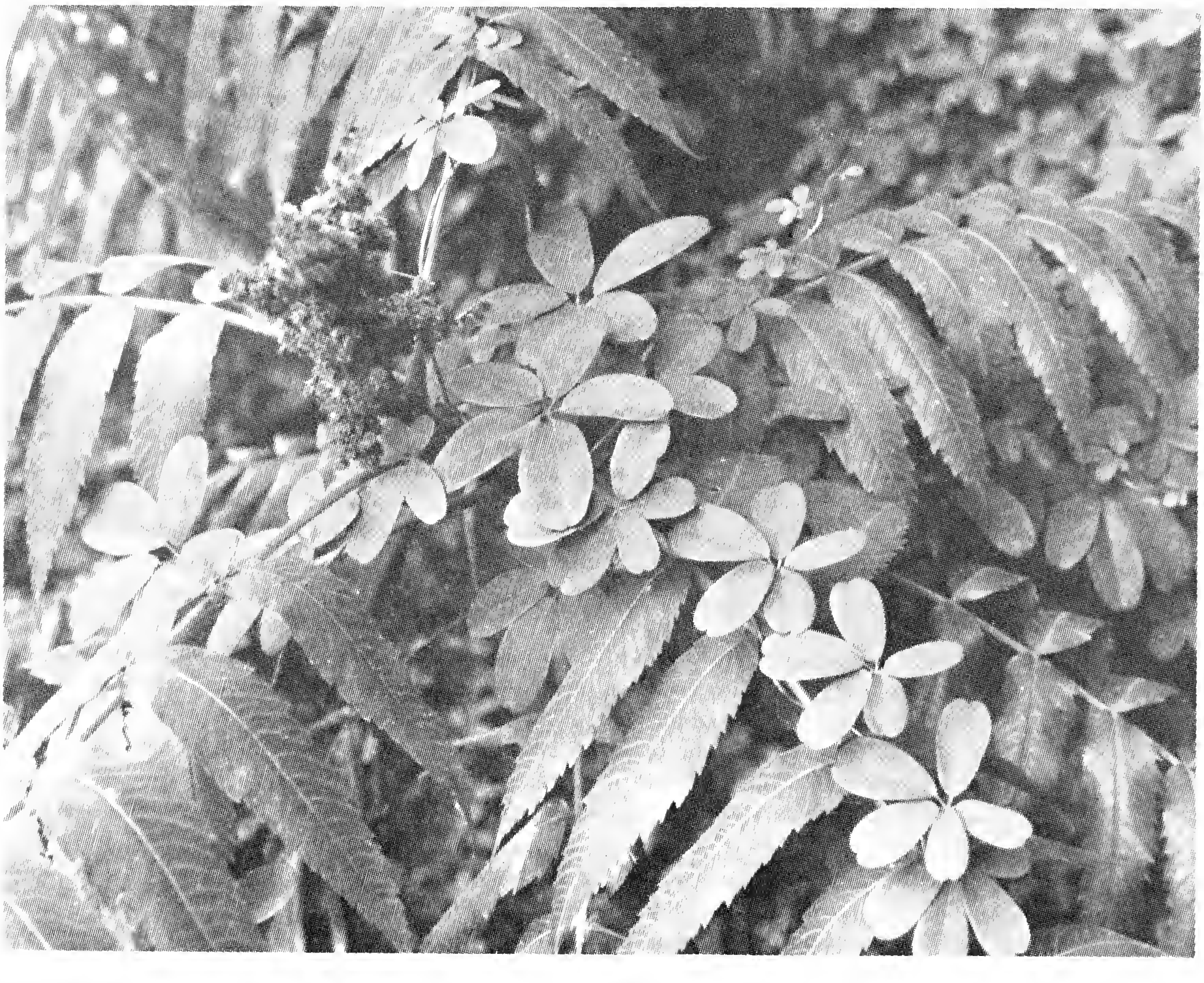

Fig. 1. *Akebia quinata* climbing on *Rhus typhina*, Ann Arbor, Michigan, September 1973. (Photo by B. E. Levenson)

Ernst, Wallace R. 1964. The genera of Berberidaceae, Lardizabalaceae, and Menispermaceae in the southeastern United States. Jour. Arnold Arb. 45: 1-35.
Fernald, Merritt Lyndon. 1950. Gray's Manual of Botany. 8th ed. Am. Book Co., New York. lxiv + 1632 pp.
Fogg, John M., Jr. 1930. A few noteworthy plants from Falmouth, Massachusetts. Rhodora 32: 103-110.
Payne, Willard W., & James L. Seago. 1968. The open conduplicate carpel of Akebia quinata (Berberidales: Lardizabalaceae). Am. Jour. Bot. 55: 575-581.

MICHIGAN PLANTS IN PRINT
New Literature Relating to Michigan Botany

This section lists new literature relating to Michigan botany under four categories: A. Maps, Soils, Geology, Climate (new maps and selected bulletins or articles on matters useful to field naturalists and students of plant distribution); B. Books, Bulletins, etc., and C. Journal Articles (listing, respectively, all separate publications and articles in other periodicals which cite Michigan specimens or include research based on plants of wild origin in Michigan—not generally including work on cultivated plants nor strictly economic aspects of forestry, conservation, or agriculture); D. History, Biography, Exploration (institutions as well as travels and lives of persons with Michigan botanical connections). When the subject matter or relation to Michigan is not clear from the title, annotations are added in brackets. Readers are urged to call to the editor's attention any titles (1960 or later) which appear to have been overlooked—especially in less well known sources.

—E. G. V.

A. MAPS, SOILS, GEOLOGY, CLIMATE, GENERAL

Farrand, W. R., & D. F. Eschman. 1974. Glaciation of the Southern Peninsula of Michigan: A review. Mich. Academ. 7: 31-56. [Includes correlation chart, maps, and diagrams.]

Forsyth, Jane L., & Ernest S. Hamilton. 1974. Possible origin of unexpectedly high alkalinities in quartz sands of high dunes at Warren Dunes State Park, Michigan. Ohio Jour. Sci. 74: 182-184. [Spray from Lake Michigan considered a principal source of carbonates producing pH values of 7.9.]

Waltrip, David A. 1973. Sourcebook and Field Guide to the Geology of the West-Central Lower Peninsula of Michigan. Dep. Geol., West. Mich. Univ. Publ. ES-2. 145 pp. $3.00. [Prepared especially for secondary earth science teachers. Among the features included are descriptions of geologic sites of interest in Benzie, Grand Traverse, Lake, Leelanau, Manistee, Mason, Muskegon, Newaygo, Oceana, and Wexford counties, along with maps of the surface geology of each of these counties.]

(U.S. Geological Survey). The following topographic maps for Michigan have been published since the previous listing in our March 1974 issue and are available at $.75 each from Branch of Distribution, U.S. Geological Survey, 1200 South Eads St., Arlington, Virginia 22202. Maps are supplied folded, and with green overprint showing wooded areas, unless contrary requests are made. All maps listed here are 7½-minute quadrangles (scale of 1:24,000 or about 2½ inches to a mile) and are new or resurveyed, except those marked with an asterisk, which are photorevisions (not field-checked). Following the name of the quadrangle, the county or counties in which it primarily lies are added.

Adams Point [Presque Isle]
Algonac* [St. Clair + Ontario]
Alpena [Alpena]
Alvordton* [Hillsdale + Ohio]
Ann Arbor East* [Washtenaw]
Auburn* [Bay, Saginaw]
Aurelius* [Ingham]
Bath [Clinton]
Bay City* [Bay]
Bay City NE* [Bay]
Belding [Ionia]
Belle Isle* [Wayne + Ontario]
Belleville* [Wayne]
Birch Run South* [Saginaw]
Birmingham* [Oakland]
Black River [Alcona]
Bridgeport* [Saginaw]
Cannonsburg [Kent]
Clear Lake* [Hillsdale + Ohio]
Constantine [St. Joseph]
Crump* [Bay]
Dearborn* [Wayne]
Denton* [Washtenaw, Wayne]
Detroit* [Wayne]
Dimondale* [Eaton]
Eaton Rapids* [Eaton]
Essexville* [Bay]
Evans [Kent]
Fairgrove* [Tuscola]
Fish Point* [Tuscola]
Flat Rock* [Monroe, Wayne]
Flat Rock NE* [Wayne]
Frankenmuth* [Tuscola, Saginaw]
Gilford* [Tuscola]
Greenville East [Montcalm]
Greenville West [Montcalm, Kent]
Hawks [Presque Isle]
Highland Park* [Wayne, Macomb]
Kalamazoo* [Kalamazoo]
Kalamazoo NE* [Kalamazoo, Allegan]
Kalamazoo SW* [Kalamazoo]
Kawkawlin* [Bay]
Klinger Lake [St. Joseph]
Lachine [Alpena]
Laingsburg [Shiawassee]
Lake Winyah [Alpena]
Lansing North* [Clinton]
Lansing South* [Ingham]
Long Lake East [Alpena, Presque Isle]
Long Lake West [Alpena, Presque Isle]
Metz [Presque Isle]
Middle Island [Alpena]
Midland North* [Midland, Bay]
Midland South* [Midland, Bay, Saginaw]
Moltke [Presque Isle]
Nettle Lake* [Hillsdale + Ohio]
North Point [Alpena]
Northville* [Oakland, Wayne]
Ossineke [Alpena]
Otsego* [Allegan, Kalamazoo]
Pinconning* [Bay]
Polaski [Alpena, Presque Isle]
Port Huron* [St. Clair + Ontario]
Portage* [Kalamazoo]
Posen [Presque Isle]
Presque Isle [Presque Isle]
Price [Clinton]
Quanicassee* [Bay, Tuscola]
Reese* [Tuscola, Saginaw]
Rogers City [Presque Isle]
Saginaw* [Saginaw]
Saginaw NE* [Saginaw]
St. Clair* [St. Clair + Ontario]
St. Johns South* [Clinton]
Schoolcraft* [Kalamazoo, St. Joseph]
Schoolcraft NW* [Kalamazoo]
Shaftsburg [Shiawassee]
Sheridan [Montcalm]
Shiloh [Ionia]
Smyrna [Ionia, Kent]
South Point [Alpena]
Spruce [Alcona]
Standish* [Arenac, Bay]
Thompsons Harbor [Presque Isle]
Three Rivers East [St. Joseph]
Thunder Bay Island [Alpena]
Vassar* [Tuscola]
Vicksburg* [Kalamazoo, St. Joseph]
Wacousta* [Clinton]
Willard* [Bay]
Ypsilanti West* [Washtenaw]

C. JOURNAL ARTICLES

Anderson, Roger C., & Orie L. Loucks. 1973. Aspects of the biology of Trientalis borealis Raf. Ecology 54: 798-808. [Distribution map for North America includes many dots in Michigan; field data from Wisconsin.]

Barnes, Burton V. 1969. Natural variation and delineation of clones of Populus tremuloides and P. grandidentata in northern Lower Michigan. Silvae Genetica 18: 130-142. [Based on studies conducted near Pellston.]

Barnes, Burton V., Bruce P. Dancik, & Terry L. Sharik. 1974. Natural hybridization of

yellow birch and paper birch. For. Sci. 20: 215-221. [The hybrid is reported from Michigan, without further locality data, as well as Minnesota and New Hampshire.]
Barnes, William J., & Grant Cottam. 1974. Some autecological studies of the Lonicera ×bella complex. Ecology 55: 40-50. [Map of North American distribution includes several dots in Michigan; field data from Wisconsin.]
Brown, Robert T. 1974. Furnace fuel, air pollution accumulated in snow and lichen growth on trees. Mich. Academ. 7: 149-156. [Study in the Houghton-Hancock area.]
Coblentz, Bruce E. 1970. Food habits of George Reserve deer. Jour. Wildlife Managem. 34: 535-540. [Includes general description of vegetation of the tract, about 25 miles NW of Ann Arbor, and analyses of rumen contents.]
Currier, Paul J., & Ronald O. Kapp. 1974. Local and regional pollen rain components at Davis Lake, Montcalm County, Michigan. Mich. Academ. 7: 211-225. [Study of contemporary pollen at a bog from which post-Wisconsin pollen sequences have been published. Excessive taxonomic caution is shown in referring to "*Chamaedaphne* sp." when the genus includes only a single species in the entire world!]
Dancik, Bruce P., & Burton V. Barnes. 1974. Leaf diversity in yellow birch (Betula alleghaniensis). Canad. Jour. Bot. 52: 2407-2414. [Study based on material from Iron and Washtenaw counties.]
Donnelly, John R. 1974. Seasonal changes in photosynthate transport within elongating shoots of Populus grandidentata. Canad. Jour. Bot. 52: 2547-2559. [Field research done in area of University of Michigan Biological Station.]
Elliott, Mary E., & Modra Kaufert. 1974. Peziza badia and Peziza badio-confusa. Canad. Jour. Bot. 52: 467-472. [Only the former cited from Michigan (Douglas Lake) but both mapped near northern tip of the Lower Peninsula.]
Gysel, Leslie W. 1971. a 10-year analysis of beechnut production and use in Michigan. Jour. Wildlife Managem. 35: 516-519. [Records from woodlots near East Lansing.]
Harms, Vernon L. 1973. Taxonomic studies of North American Sparganium. I. S. hyperboreum and S. minimum. Canad. Jour. Bot. 51: 1629-1641. [Collections of *S. minimum* cited from 10 Michigan counties, but Isle Royale erroneously located in Gogebic Co.—and the species not mapped from Isle Royale.]
Holt, Bulford R. 1972. Effect of arrival time on recruitment, mortality, and reproduction in successional plant populations. Ecology 53: 668-673. [Study of *Daucus carota* in old fields in Kalamazoo Co.]
Kessler, Kenneth J., Jr. 1965. Dieback of managed, old-growth northern hardwoods in Upper Michigan, 1954-1964—A case history. Pl. Disease Rep. 49: 483-486. [Observations in Marquette Co.]
Kessler, Kenneth J., Jr. 1969. Top-dying of yellow birch associated with seed production. Pl. Disease Rep. 53: 694-697. [Observations "throughout Michigan and Wisconsin."]
Kohlmeyer, Jan & Erika. 1974. Distribution of Epichloë typhina (Ascomycetes) and its parasitic fly. Mycologia 66: 77-86. [Two grass hosts of the fungal parasite are cited from Michigan: *Hystrix patula* (both vars.) and *Glyceria striata.*]
Krug, J. C., & R. F. Cain. 1974. New species of Hypocopra (Xylariaceae). Canad. Jour. Bot. 52: 809-843. [Type of *H. stephanophora* is from Ingham Co.: G. H. Hicks' "Plants of Michigan" No. 1754.]
Kullberg, Russell G. 1974. Distribution of aquatic macrophytes related to paper mill effluents in a southern Michigan stream. Am. Midl. Nat. 91: 271-281. [Study in Portage Creek, Kalamazoo Co.]
Jones, Almut G. 1974. Aster ericoides L. east of the Mississippi River. Am. Midl. Nat. 92: 466-475. [Distribution map shows both var. *ericoides* and var. *prostratus* at several localities in southern half of Lower Peninsula.]
Liberta, Anthony E. 1973. The genus Trechispora (Basidiomycetes, Corticiaceae). Canad. Jour. Bot. 51: 1871-1892. [Michigan included in range of 3 species but specimens are not among those selected for citation.]
Momot, Walter T., & Howard Gowing. 1972. Differential seasonal migration of the crayfish, Orconectes virilis (Hagen) in marl lakes. Ecology 53: 479-483. [Includes very brief observations on the limited aquatic vegetation of North Twin, South Twin, and West Lost lakes, Otsego Co.]

Murdoch, William W., Francis C. Evans, & Charles H. Peterson. 1972. Diversity and pattern in plants and insects. Ecology 53: 819-829. [Studies on the George Reserve.]

Olive, Lindsay S., & Carmen Stoianovitch. 1974. A cellular slime mold with flagellate cells. Mycologia 66: 685-690. [Michigan is one of 3 states from which *Pocheina rosea* is known in the U.S.]

Ozoga, John J. 1966. Winter activities and feeding habits of northern Michigan coyotes. Jour. Wildlife Managem. 30: 809-818. [Beechnuts appeared in coyote scats on Beaver Island with frequency of 8.3%.]

Pfister, Donald H. 1973. The psilopezioid fungi. IV. The genus Pachyella (Pezizales). Canad. Jour. Bot. 51: 2009-2023. [Three species cited from Michigan, and holotype of P. punctispora is from Cheboygan Co.]

Pfister, Donald H., & Richard P. Korf. 1974. The psilopezioid fungi. V. Miladina lechithina. Canad. Jour. Bot. 52: 1643-1645. [Cited from Michigan without further locality data.]

Rockett, Timothy R., & C. L. Kramer. 1974. The biology of sporulation of selected Tremellales. Mycologia 66: 926-941. [Some of the field studies were conducted at the University of Michgian Biological Station.]

Savile, D. B. O. 1972. Some rusts of Scirpus and allied genera. Canad. Jour. Bot. 50: 2579-2596. [Michigan host records cited for *Puccinia dulichii* (on *S. atrovirens* & *S. cyperinus*) and *P. obtecta* (on *S. validus*).]

Schwintzer, Christa R., & Gary Williams. 1974. Vegetation changes in a small Michigan bog from 1917 to 1972. Am. Midl. Nat. 92: 447-459. [Study of Bryant's Bog, Cheboygan Co.]

Smith, Alexander H. 1973. Notes on Michigan Boletaceae. Persoonia 7: 321-331. [Supplements "The Boletes of Michigan" with descriptions of new taxa and notes on old ones.]

Sparrow, Frederick K. 1974. Observations on chytridiaceous parasites of phanerogams. XIX. A Physoderma on Eurasian water milfoil (Myriophyllum spicatum). Am. Jour. Bot. 61: 174-180. [A new species from Oakland Co.]

Sparrow, F. K. 1974. Observations on chytridiaceous parasites of phanerogams. XX. Resting spore germination and epibiotic stage of Physoderma butomi Schroeter. Am. Jour. Bot. 61: 203-208. [Studies on material from Oakland Co.]

Stoermer, Eugene F., & Jing Jing Yang. 1971. Contributions to the diatom flora of the Laurentian Great Lakes. I. New and little-known species of Amphora (Bacillariophyta Pennatibacillariophyceae). Phycologia 10: 397-409. [Types of several new species and other records from Michigan waters.]

Taylor, Jane, Peggie J. Hollingsworth, & Wilbur C. Bigelow. 1974. Scanning electron microscopy of liverwort spores and elaters. Bryologist 77: 281-327. [Material of *Blasia pusilla* came from Michigan.]

Vitt, Dale H., & Catherine D. Hamilton. 1974. A scanning electron microscope study of the spores and selected peristomes of the North American Encalyptaceae (Musci). Canad. Jour. Bot. 52: 1973-1981. [Material of *E. procera* is cited from Alpena Co.]

Watling, Roy. 1971. The genus Conocybe subgenus Pholiotina II. Persoonia 6: 313-339. [Several collections of 2 species are fully cited from Michigan localities.]

Webb, Thompson, III. 1974. Corresponding patterns of pollen and vegetation in Lower Michigan: A comparison of quantitative data. Ecology 55: 17-28. [Modern pollen and vegetation data for the Lower Peninsula, with numerous maps.]

Williams, Louis G. 1972. Plankton diatom species biomasses and the quality of American rivers and the Great Lakes. Ecology 53: 1038-1050. [Includes data from Port Huron, Detroit, and Sault Ste. Marie.]

Zumberge, James H., & William S. Benninghoff. 1969. A mid-Wisconsin peat in Michigan, U.S.A. Poll. Spores 11: 585-601. [Stratigraphic and pollen data from a lacustrine deposit near Grand Rapids, apparently dating from the Port Talbot Interstade (between Early and Late Wisconsin).]

Editorial Notes

We remind prospective authors to read carefully "Information for Authors" on page 190 of the October 1974 issue. Please submit manuscripts in duplicate, completely double-spaced, and following the style of this journal in regard to literature citations, headings, etc.

We reinforce the plea to readers on p. 107, that they call to the editor's attention any titles published since 1960 which seem to have been overlooked in the listings of "New Literature Relating to Michigan Botany"; papers for which reprints are received are likely to be listed more promptly than if they are discovered later in routine search when volumes are neither in circulation nor being bound at the library!

Finally, to conclude these "housekeeping matters," we remind all readers about address changes. It costs a large share of our modest subscription rate to process a copy returned because of an incorrect address. Members of the Michigan Botanical Club, who receive the journal as one of the privileges of membership, should submit address changes to the appropriate chapter officer, as the chapters are solely responsible for their mailing lists. Non-member subscribers, and no others, should send address changes to the business and circulation manager (see inside cover). No address change should be sent to anyone at the University of Michigan Herbarium, for we only have to remail them elsewhere.

The January number (Vol. 14, No. 1) was mailed January 22, 1975.

Publications of Interest

THE THISTLES OF CANADA. By R. J. Moore and C. Frankton. Canada Dep. Agr. Monogr. 10. 1974. 112 pp. A fully illustrated guide to the tribe Cardueae, including not only the true thistles but also such genera as *Centaurea* and *Arctium.* There are descriptions, keys, extensive references, and distribution maps—the latter limited strictly to Canada. Differences in the status of some of our introduced species are evident: *Centaurea diffusa,* a weed in large areas of northern Michigan, where it hybridizes with *C. maculosa,* is apparently not a problem in eastern Canada and does not hybridize in that country. *Cirsium palustre,* a terrifying weed now in every county of the Upper Peninsula and recently spread south of the Straits, is "rather rare" in Canada—but the stalks are said to be edible (perhaps a better means of control than the herbicides sprayed on this thistle along Upper Peninsula highways). Available from Information Division, Canada Department of Agriculture, Ottawa K1A OC7.

A STUDENT'S ATLAS OF FLOWERING PLANTS: SOME DICOTYLEDONS OF EASTERN NORTH AMERICA. By Carroll E. Wood, Jr. Harper & Row, New York. 1974. 122 pp. $2.95. The bulk of this book is 120 pages printed on one side only (to allow rearrangement if desired) with superb drawings by eight artists illustrating selected families, including many subfamilies and other diversity within families. Several unnumbered introductory pages list descriptive terms as well as pollination and dispersal features, keyed to the fully labeled illustrations. The drawings were originally prepared for the Generic Flora of the Southeastern United States, being published serially in the Journal of the Arnold Arboretum. However, not all of the ones appearing in this volume are the same as those already published (e.g., *Cannabis* rather than *Humulus* now illustrates the Cannabaceae). The excellence of the drawings and the helpful introductory lists should make this a very useful work for students and teachers, and we hope that a companion covering the monocot families will soon be forthcoming.

—E.G.V.

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(On the cover: The achene of a sedge, Carex lurida, *magnified ca. 120×. SEM photo by Kerry S. Walter* *See pp. 67-72.)*

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THE MICHIGAN BOTANIST

May, 1975

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Articles dealing with any phase of botany relating to the Upper Great Lakes Region may be sent to the editor in chief. In preparing manuscripts, authors are requested to follow our style and the suggestions in "Information for Authors" (Vol. 13, p. 190).

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NOTES ON THE FLORA OF WISCONSIN–I. NEW AND CORRECTED DISTRIBUTION RECORDS OF BORAGINACEAE

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The University of Wisconsin, Madison 53706

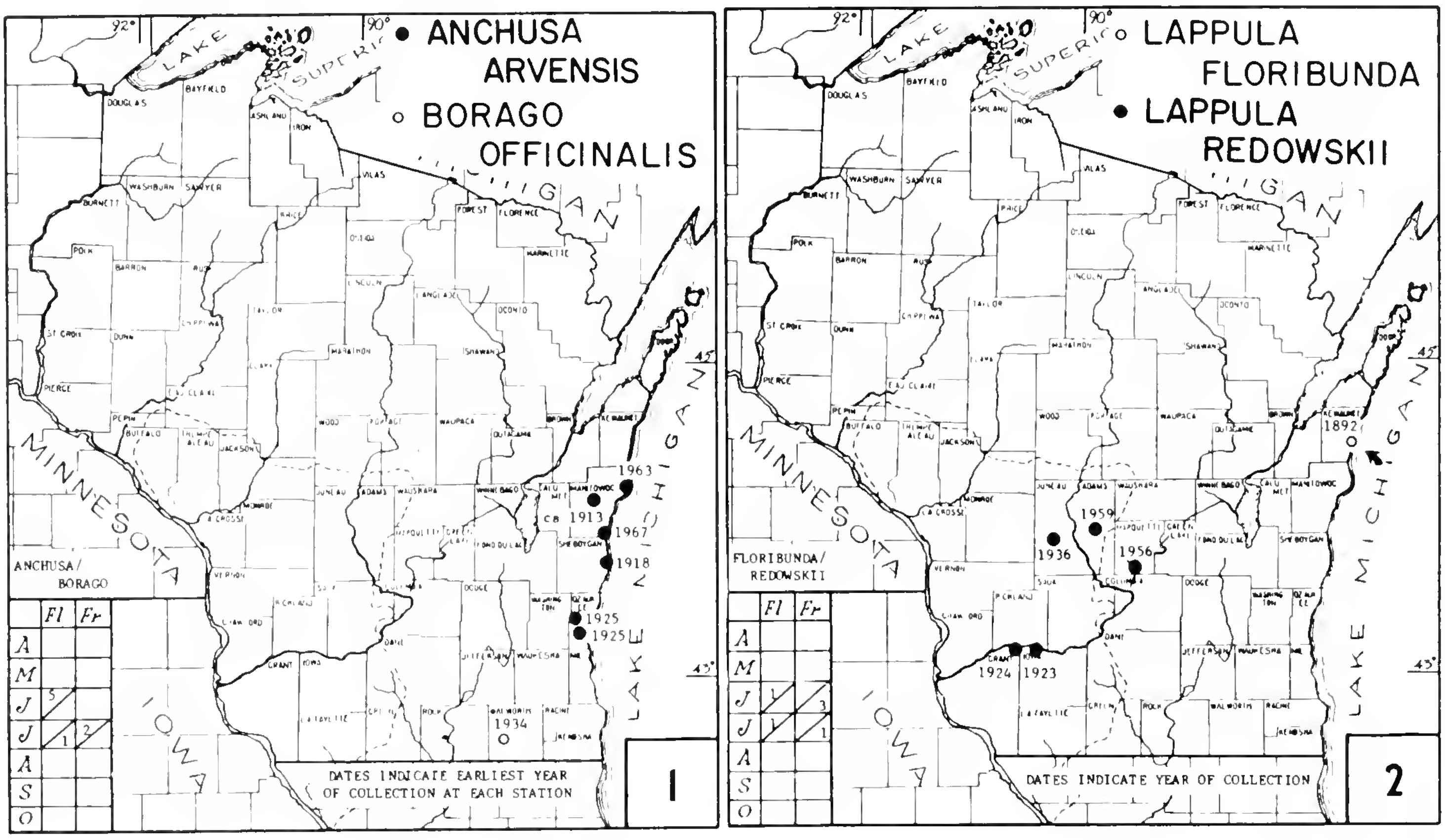
This is the first in a series of several papers presenting noteworthy information on the distribution of vascular plants in Wisconsin. It has resulted from the author's participation in a long-term project of the herbarium of the University of Wisconsin which is based on a study of the flora and phytogeography of the state as a whole and whose specific aims now are to publish (1) a map atlas of the flora of Wisconsin and (2) an annotated catalogue covering all of the vascular plants of that state. It may be some time before such an atlas can be completed. Field exploration continues to add new species to those known from Wisconsin plus additional records on the distribution of every species; and herbarium study, including the tasks of verifying the identities of Wisconsin specimens in a number of in-state herbaria as well as several other large herbaria and of evaluating all species records for the state in the published literature is time-consuming, to say nothing of the prodigious labor required to produce the maps themselves.

In the present paper additional records of Wisconsin Boraginaceae are published, including two species not previously recorded from the state. Specimens and references, whether to journal papers, manuals, or monographs, are cited to document the statements under each entry. Unexplained references to "voucher" or "vouchers" apply to dots on maps in E. P. Kruschke's report (1946) on the Boraginaceae of Wisconsin. These references are included in order to correct published records by him and later workers which were based on misidentifications.

EXPLANATION OF THE MAPS AND ACKNOWLEDGMENTS

The distribution maps and dates of flowering and fruiting are based on specimens deposited in the following institutional herbaria: University of Wisconsin–Madison (WIS), University of Wisconsin–Milwaukee (UWM), University of Wisconsin–Oshkosh (OSH), University of Wisconsin–Stevens Point (UWSP), University of Wisconsin–Superior (SUWS), Univeristy of Wisconsin–Whitewater (UWW), University of Wisconsin Center–Janesville (UWJ), Milwaukee Public Museum (MIL), Beloit College (BELC), and the University of Minnesota (MIN). Except for triangles, which denote county records only, symbols indicate specific localities. Minnesota, Iowa, and Illinois records are from herbarium specimens (WIS) and localities cited in Hartley (1962), Lakela (1965), Morley (1969), and Winterringer and Evers (1960).

I am grateful to the authorities of seven of the above institutions for placing their facilities at my disposal when I visited them or for loaning Wisconsin specimens under their care. I am obliged to a number of persons who have generously supplied me with information in correspondence regarding certain significant records, particularly to Neil A. Harriman (University of Wisconsin–Oshkosh), also to Almut G. Jones (University of Illinois), David Kopitzke (Milwaukee Public Museum), Paul H. Monson (University of



Figs. 1-2. Maps showing distributions of borages in Wisconsin: (1) *Anchusa arvensis* (dots) and *Borago officinalis* (circle); (2) *Lappula floribunda* (circle) and *L. redowskii* (dots).

Minnesota–Duluth), Gerald B. Ownbey (University of Minnesota), Alvin M. Peterson (Onalaska, Wisconsin), S. Galen Smith (University of Wisconsin–Whitewater), and Floyd Swink (Morton Arboretum).

Amsinckia lycopsoides Lehm. (*A. barbata*)

The identity of the earliest Manitowoc Co. collection (*H. Benke 891* in 1912, MIL) is a little uncertain. It consists of three plants whose fruiting calyces are clearly 4- or mostly only 3-parted by fusion of two or four of the parts in pairs, and therefore it might be keyed out to *Amsinckia tessellata* if other characters indicated in Ray and Chisaki's key (Am. Jour. Bot. 44: 530. 1957) are not checked. Aided by the dissection of a water-soaked flower, one individual was seen to bear flowers possessing both 3- and 5-parted calyces.

I am treating all six known Wisconsin collections of *Amsinckia* as *A. lycopsoides.*

Anchusa arvensis (L.) Bieb. (*Lycopsis a.*) (Fig. 1).

MANITOWOC CO.: upper sand dune near lighthouse, Point Beach St. Pk., *D. Misner s.n.,* 21 Jul 1963 (WIS); a single plant, sandy Lake Michigan beach just off Hwy. LS, Cleveland. *N. Harriman 2124,* 29 Jul 1967 (SUWS, UWM).

Small bugloss or alkanet is now represented by at least seven collections from east-central Wisconsin.

The Jackson Co. collection cited by Hartley (1966, p. 70) is *Anchusa officinalis* (q.v.).

As treated by Chater in Tutin et al. (1972, pp. 106-109), *Lycopsis* L. is included in the genus *Anchusa* L.

Anchusa officinalis L.

JACKSON CO.: grassy lot, Indian Mission, 6 mi. NE of Black River Falls, sec. 33, T22N, R3W, *D. Grether 6065,* 16 Jul 1947 (MIL, WIS).

This collection is the third record for Wisconsin, Kruschke (1946, pp. 279, 280) and Swink (1974, p. 22) having cited specimens from Milwaukee and Walworth Cos. respectively.

Borago officinalis L. (Fig. 1).

WALWORTH CO.: appearing spontaneously in Earl Shepard's garden and increasing from year to year, [Delavan,] *S. Wadmond s.n.,* 3 Jul 1934 (WIS).

This native of Europe is not included in Kruschke's treatment (1946), even though Johnston (1924, p. 7) specifically attributed it to Wisconsin. Because the latter reference either has been overlooked or, on account of lack of specimens, discounted by contemporary workers, the above collection is cited so that there will be no doubt of the occurrence of borage as a casual escape or introduction in the state.

Cynoglossum boreale Fern.

Northern wild comfrey occurs frequently in the northern part of Wisconsin, but it soon becomes rare southward and does not cross the "Tension Zone" except for occasional local stations along the Lake Michigan shoreline and the Grant Co. locality, which is based on a specimen collected by C. H. Sylvester and labeled "Coon Branch Wis." A later hand in different ink added "near Boscobel" to the data on the original label. I have examined a number of Sylvester specimens in the herbarium of the Milwaukee Public Museum and have no reason to question any as not representing reliable records. Nothing is known biographically about this collector, who, according to the museum's accession catalogues, sent to that institution specimens he collected from 1882 to 1886 inclusive and in 1888 (Kruschke, pers. comm.). These collections are all from four counties bordering the lower Wisconsin River, and most are from the Boscobel area. At least six bear the same "Coon Branch" notation, an evident reference to the Coon Valley of the U.S. Geological Survey maps. That valley runs east-west through secs. 21, 22, 23, 24, and 13 of Hickory Grove Twp., T7N, R2W, about nine miles southeast of Boscobel, and lies in the center of the "Driftless Area," a region famous for small pockets in which northern species persist.

The Baileys Harbor (Door Co.) and Madison (Dane Co.) vouchers are *Cynoglossum officinale* and *Lappula virginiana* (*Hackelia v.*) respectively.

Lappula deflexa (Wahlenb.) Garcke ssp. **americana** (Gray) Cochrane, stat. nov. *Echinospermum deflexum* var. *americanum* Gray, Proc. Am. Acad. 17: 224. 1882. *Hackelia americana* (Gray) Fern. *Lappula americana* (Gray) Rydb. *Lappula deflexa* var. *americana* (Gray) Greene.

Fernald (Rhodora 40: 341-343. 1938) showed that American plants do not match exactly those from Eurasia. Now considering the former to comprise a species distinct from *Lappula deflexa,* he discarded the varietal treatment he and Johnston had proposed earlier (Rhodora 26: 124. 1924). However, the two taxa seem to be essentially similar, differing mainly in corolla size and also in several other minor qualitative and quantitative tendencies. I prefer to recognize *americana* at the subspecific level because of the occurrence of the two types and because of their geographic distributions.

Lappula floribunda Greene (*Hackelia f.*) (Fig. 2).

KEWAUNEE CO.: railroad ditch west of water tank, Kewaunee, *J. Schuette 38622,* 11 Jun 1892 (WIS); same location, *J. Schuette 38623,* 26 Jul 1892 (WIS). Specimens determined with Dr. H. H. Iltis.

Apparently a waif, whose occurrence in Wisconsin is reported here for the first time. Fernald (1950, p. 1208) gives the distribution of this plant as "...Pacific slope and Rocky Mts., e. to w. Ont. and Minn." Gleason and Cronquist (1963, p. 577) indicate the same eastern limit, "...reputedly w. Ont. and Minn."

The specimens were identified by Kruschke as "Prob. L. Redowskii var. occidentalis," but because of their immature fruit they were not mapped by him. The discernment of the collector is noteworthy, for his original determination reads "Echinospermum floribundum Lehm."

Lappula redowskii (Hornem.) Greene (incl. var. *occidentalis*) (Fig. 2).

MARQUETTE CO.: upland sandy prairie, with *Stipa spartea* and *Carex* spp., NW shore of Ennis [Muir] Lake, sec. 14, T14N, R9E, *H. Iltis, G. Trenk, & G. Noamesi 6197,* 14 Jul 1956 (WIS); additional specimen with otherwise identical data, *H. Iltis, G. Trenk, & G. Noamesi 6270* (WIS).

These specimens and those from Adams (Adams Co.), Avoca (Iowa Co.), New Lisbon (Juneau Co.), and Muscoda (Grant Co.) definitely restrict the local range of this rare western adventive to southwest-central Wisconsin.

The Sheboygan (Sheboygan Co.) and Madison (Dane Co.) vouchers are *Lappula americana* (*Hackelia a.*) and *L. echinata* respectively, and the two Schuette specimens mentioned by Kruschke (1946, p. 277) as possibly being *L. redowskii* are *L. floribunda* (*Hackelia f.*) (q.v.).

Lithospermum latifolium Michaux

The Fountain City (Buffalo Co.) voucher is *Lappula virginiana* (*Hackelia v.*). American gromwell is still unknown from that county.

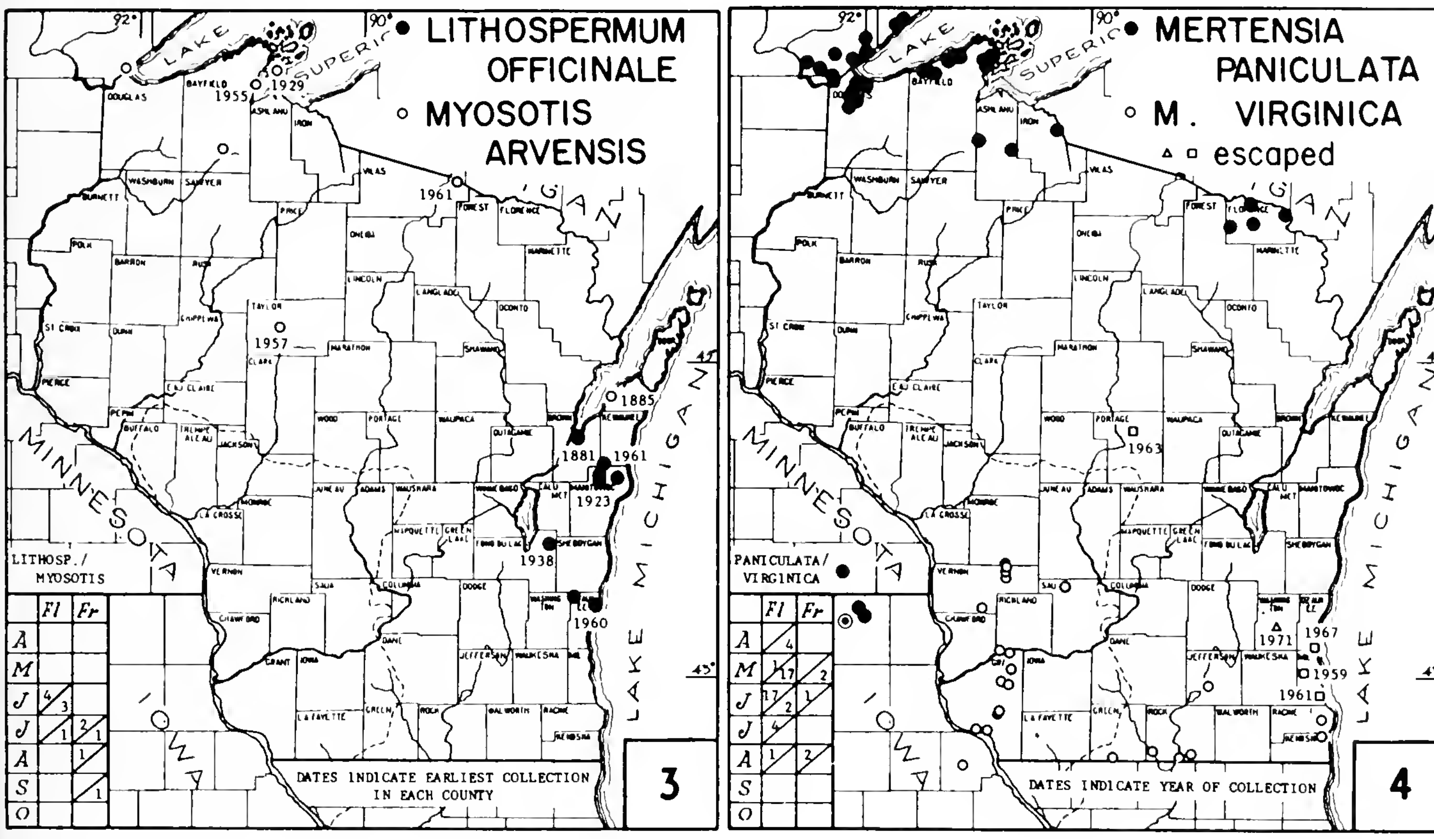
Lithospermum officinale L. (Fig. 3).

KEWAUNEE CO.: common, near Buck Creek, sec. 31, T22N, R23E, *M. Johnson s.n.,* 5 June 1961 (WIS). OZAUKEE CO.: low dunes behind beach strand with *Ammophila breviligulata, Agropyron dasystachyum* var. *psammophilum, Calamovilfa longifolia* var. *magna,* and *Lathyrus japonicus* var. *glaber*; also in adjacent wooded areas, 4 mi. NE of Port Washington, secs. 1 & 11, T11N, R22E, *H. Iltis 20293,* 2 Jun 1962 (MIL, WIS); quite frequent in scattered clumps, with *Lappula echinata, Cynoglossum officinale, Cirsium arvense, C. vulgare,* and *Achillea millefolium* on dry morainal hills with scattered *Quercus macrocarpa* and *Carya ovata,* sec. 6, T12N, R21E, *E. Kruschke K-50-60,* 16 Jul 1960 (MIL); occasional to quite frequent in places, same location, *E. Kruschke K-60-17,* 2 Jun 1960 (MIL).

The present collections add two more Wisconsin counties to the four previously reported for common gromwell.

Mertensia paniculata (Ait.) G. Don (Fig. 4).

ASHLAND CO.: wet sedgey ground near spring-fed stream, in *Acer rubrum-Thuja occidentalis* woods with *Betula, Ribes, Streptopus amplexifolius* var. *denticulatus,* and *S. roseus* var. *longipes,* S of Eagles Peak, sec. 11, T44N, R2W, *J. Schwarzmeier 20,* 7 Aug 1971 (WIS).



Figs. 3-4. Maps showing distributions of borages in Wisconsin and portions of adjacent states: (3) *Lithospermum officinale* (dots) and *Myosotis arvensis* (circles); (4) *Mertensia paniculata* (dots) and *M. virginica* (circles, squares, triangle).

There are now five counties known for this species. Additional collections and the examination of other herbaria for Wisconsin specimens have tripled the number of stations previously reported, indicating that *Mertensia paniculata,* while apparently confined to the northern tier of counties, is probably frequent in swampy forests there.

Mertensia virginica (L.) Pers. (Fig. 4).

JEFFERSON CO.: grazed oak woods, N of Ft. Atkinson, sec. 27, T6N, R14E, *E. Fuge A67-30,* 6 May 1967 (BELC). RICHLAND CO.: abundant, steep SE-facing slope beneath cliffs in mesic *Tilia americana-Celtis occidentalis* woods, sec. 6, T8N, R2W, *M. Nee 1774,* 20 Apr 1969 (WIS). SAUK CO.: roadside through dense woods, sec. 13, T13N, R3E, *C. Lemke 18,* 2 Jun 1956 (WIS). MILWAUKEE CO.: damp wooded ravine, Grant Park, South Milwaukee, *J. Dzelzkalns s.n.,* 26 Apr 1961 (UWM); edge of woods, 88 St., Wauwatosa, *E. Fitting s.n.,* 24 May 1959 (UWM). OZAUKEE CO.: common, rich woods atop Lake Michigan bluff, N. Lakeshore Dr., Mequon, *L. Musselman 58,* 15 Apr 1963 (UWM). PORTAGE CO.: wet woods, [7 mi. NE of Stevens Point,] sec. 12, [T24N, R8E,] *W. Schimpff Y:2-5,* 17 May 1963 (UWSP). WASHINGTON CO.: low open area near small stream, near Oriole La. ca. 1 mi. off Bonniwell Rd., *R. Martin s.n.,* 14 May 1971 (UWM).

This species, while previously known to be present at several stations in six southern Wisconsin counties, is infrequent and local in its natural occurrence. Of the collections cited above, all of which constitute records from new counties, only the first two clearly represent native colonies. From among the numerous specimens examined at various herbaria I accepted five as being legitimate records of escaped plants.

Bluebells is often cultivated in wild-flower gardens. It grows very well in loam soil on wooded homesites in the Madison, Milwaukee, La Crosse, and

Stevens Point areas, and colonies gradually increase in size as plants reseed themselves over the years.

Myosotis arvensis (L.) Hill (Fig. 3).

BAYFIELD CO.: Washburn, *R. Horner s.n.,* 5 Sep 1955 (WIS); roadside gravel, Camp Shewahmegon, sec. 7, T44N, R7W, *R. Schlising 821,* 27 Jun 1958 (WIS). TAYLOR CO.: mesic *Acer saccharum-Tilia americana* woods with hills and depressions, Lake Kathryn, sec. 4, T31N, R2W, *H. Gale & G. Struik s.n.,* 19 Jun 1957 (WIS). VILAS CO.: sandy roadside through dense *Acer saccharum* forest and escaped into woods, Simpson estate, SE end of Lac Vieux Desert, secs. 11 & 12, T42N, R11E, *H. & C. Iltis 18069,* 16 Jul 1961 (WIS).

This species was previously known from three widely scattered coastal counties, Ashland, Door, and Sheboygan. J. H. Schuette (*38799,* WIS) first collected it in 1885 on the shores of Green Bay in what must be Door Co. The label gives "Sugar creek, Bay shore" as the locality, without indicating the county. There is a small gravelly stream called Sugar Creek whose mouth drains into the bay (sec. 25, T27N, R23E) twenty-six miles above the city of Green Bay, a location lying within the range of the botanical activities of that productive collector.

The Racine Co. voucher is *Myosotis sylvatica* (q.v). Vouchers for *M. arvensis* at Fish Creek (Door Co.) and Sheboygan (Sheboygan Co.) must be based on specimens in herbaria not checked by me; I have not seen collections in support of these records.

Myosotis laxa Lehm.

CHIPPEWA CO.: rocky flats and shores along Chippewa River, Jim Falls, sec. 30, T30N, R7W, *J. Patman, R. Long, & G. Struik s.n.,* 26 Jun 1959 (WIS).

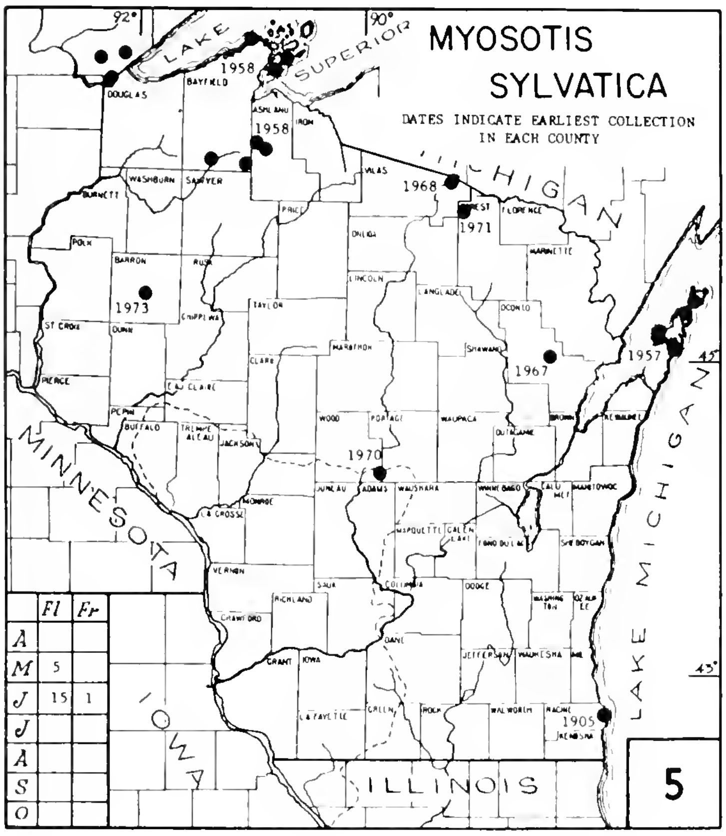
Considering the apparent rarity of the smaller forget-me not in Wisconsin and its distinct narrow distribution in the much botanized southern quarter of the state, it may be well to list the above station in Chippewa Co., which is approximately 125 miles northwest of the location on Blackhawk Island reported for the Wisconsin Dells by Hartley (1962, p. 423).

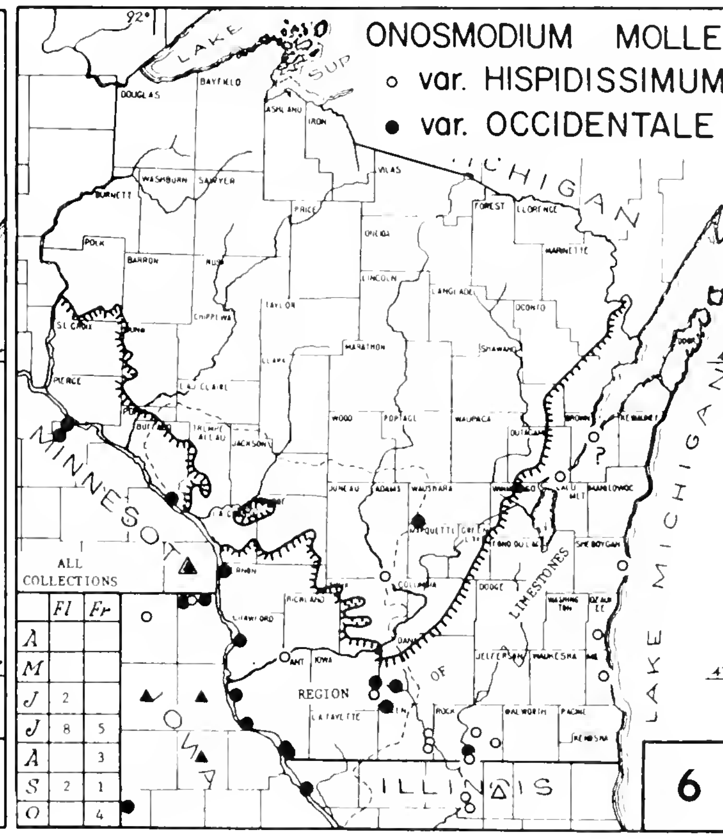
Myosotis scorpioides L.

The Waupaca Co. voucher is *Veronica americana,* but additional specimens from this county have been seen: Clintonville School Forest (*J. Mauritz 1339* in 1965, WIS); wayside near Marion (*K. Rill s.n.* in 1959, WIS).

Myosotis sylvatica Hoffm. (Fig. 5).

ASHLAND CO.: rocky shore, E end of Madeline Island, *E. Beals AP 197,* 16 Jun 1958 (WIS); common along road through *Acer saccharum* woods with *Poa pratensis, Plantago,* and *Taraxacum officinale,* near Mineral Lake fire tower, sec. 24, T44N, R4W, *M. Nee 5122,* 8 Jun 1972 (WIS); extensive population along both sides of driveway leading to abandoned farm, on Forest Rd. 199, sec. 32, T45N, R4W, *D. Billesbach 031,* 29 May 1973 (OSH); same location, *L. Gehrke 018,* 29 May 1973 (UWM); sandy edge of road shoulder, Hwy. H opposite the lake shore, Madeline Island, sec. 27, T50N, R3W, *M. McAsey 041,* 2 Jun 1973 (MIL, OSH, UWM, WIS). BARRON CO.: moist shaded edge of lawn, Barron, sec. 28, T34N, R12W, *J. Frank s.n.,* 23 Jun 1973 (UWSP). BAYFIELD CO.: sandy shore, E side of Sand Island, *E. Beals AP 225,* 27 Jun 1958 (WIS); roadside near edge of wet woods, near Rosa Lake, [2 mi. N of Cable,] *E. Hanson 24,* 13 Jun 1970 (UWSP); moist area in swampy hardwood stand, [6 mi. E of] Namekagon, sec. 14, T43N, R5W, *G. Christopherson 137,* 14 Jun 1970 (UWSP); same location, *G. Christopherson 44,* 17 Jun 1970 (UWSP); same location, *G. Christopherson 84,* 20 Jun 1970





Figs. 5-6. Maps showing distributions of borages in Wisconsin and portions of adjacent states: (5) *Myosotis sylvatica*; (6) *Onosmodium molle* var. *hispidissimum* (circles) and *O. molle* var. *occidentale* (dots).

(UWSP). DOOR CO.: Cottage Row, Fish Creek, *H. Bennett s.n.*, 17 Jun 1957 (WIS); springy mossy crevices on open face of dolomite cliff along Lake Michigan, sec. 32, T33N, R29E, *H. Iltis & W. Buckmann 10940,* 19 Jun 1958 (WIS); pockets in Niagara Dolomite, Toft's Point, Baileys Harbor, *H. Iltis 17545,* 10 Jun 1961 (WIS); moist soil in open woods along Sunset Trail, near shore of Green Bay ca. 1 mi. N of Fish Creek, *H. Bennett 2552,* 18 Jun 1961 (WIS); in full sun on land spit extending into Lake Michigan, Bailey[s Harbor] Twp., *J. Williams s.n.,* 19 May 1968 (OSH); mixed northern hardwoods along park entrance road, 1.2 mi. from Hwy 42, Peninsula St. Pk., *J. Pieper 312*, 25 May 1968 (OSH); roadside, sandy marsh on S side of Washington Island, sec. 12, T33N, R29E, *N. Harriman 4564,* 14 Jun 1969 (OSH); one patch at edge of road pavement and several large ones appearing native in adjacent upland red oak-sugar maple forest with *Carex laxiflora, Cypripedium pubescens, Trillium grandiflorum, Viola eriocarpa, Aralia nudicaulis,* and *Aster macrophyllus,* Skyline Rd. near Sven's Panorama, Peninsula St. Pk., sec. 20, T31N, R27E, *B. Warnes & T. Cochrane 128,* 31 May 1971 (WIS); roadside ditch, [2 mi. E of Baileys Harbor,] sec. 22, T30N, R28E, *D. Nelson 013,* 5 Jun 1971 (OSH). FOREST CO.: Butternut Lake Forest Trail, on Forest Rd. 2181 along N side of Butternut Lake, sec. 28, T40N, R12E, *H. Cochrane s.n.,* 15 Jun 1971 (WIS). OCONTO CO.: roadside ditch, Hwy G along S side of Kelly Lake, sec. 6, T29N, R19E, *N. Harriman 1792,* 4 Jun 1967 (OSH). RACINE CO.: dry waste ground, Mound Cemetery, Racine, *J. Heddle 130,* 23 May 1905 (WIS). VILAS CO.: deciduous woods along dirt road, 1.4 mi. SE of Hwy. E., sec. 16, [T42N, R11E,] *R. Habighorst 155,* 30 Jun 1968 OSH). WOOD CO.: marshy area, Hwy. U between Hwy. 54 and Ten Mile Creek, [T21N, R6E,] *T. Stillman s.n.,* 28 Jun 1970 (UWSP).

In *Gray's Manual* (1950, p. 1205) the western part of the range is given as Ontario and Michigan, so the addition of this well known cultivated plant to the state's flora is not unexpected. It is becoming locally established as an escape in a number of places in northern Wisconsin, providing an example of the rapidity with which an introduced annual or biennial (biennial to perennial in this case) herb can claim possession of new territory.

The first authentic collection from Wisconsin is the specimen cited from Racine Co. It was mapped by Kruschke (1946, p. 283) as *Myosotis arvensis,* a species which now must be deleted from Swink's book (1974). The first report from Wisconsin was made by Lakela (1965, p. 490), who placed a symbol in Superior in Douglas Co. on her distribution map. Inquiries have disclosed that there is no specimen under the name *M. sylvatica* in herbaria (DUL, ILL, MIN) to support this plausible record; it may have been annotated as another species before publication of her book.

Onosmodium molle Michaux var. *occidentale* (Mack.) I. M. Johnston (Fig. 6).

DANE CO.: calcareous outcrop along town road, 2 mi. E of Mt. Horeb, *J. Thomson s.n.,* 7 Jul 1951 (WIS). GRANT CO.: scattered on S-facing, very common on SW-facing very steep dry "goat prairie," with *Bouteloua* and *Andropogon* [on bluff-top] overlooking the Mississippi River, secs. 16, 17, & 21, T1N, R2W, *H. Iltis 9447,* 9 Jul 1957 (WIS); open sandy roadside, sec. 21, T1N, R2W, *D. DeMaster s.n.,* 23 Sep 1972 (WIS); W-facing bluff prairie with *Bouteloua curtipendula, Andropogon gerardii, Celastrus scandens, Rhus glabra,* and *Aster ericoides,* 1 mi. SE of Bagley, sec 27, T5N, R6W, *M. Nee 5344,* 7 Oct 1972 (WIS); brushy prairie on SW-facing slope, with *Juniperus virginiana, Bouteloua curtipendula,* and *Rhus glabra,* Bagley, sec 16, T5N, R6W, *M. Nee 5340,* 7 Oct 1972 (WIS); common in places, bluff prairie, with *Bouteloua curtipendula, Andropogon scoparius,* and *Kuhnia eupatorioides,* Cassville, sec. 20, T2N, R5W, *M. Nee 5407,* 14 Oct 1972 (WIS). IOWA CO.: Thousand's Rock Point Prairie, [4 mi. SE of Barneveld,] sec. 24, T6N, R5E, *H. Iltis & J. Thomson s.n.,* 21 Jul 1964 (WIS). GREEN CO.: abundant, high prairie relict, with *Psoralea, Petalostemum purpureum,* and *Kuhnia,* sec. 4, [T4N, R6E,] *H. Greene & J. Zimmerman s.n.,* 23 Jul 1948 (WIS); high prairie remnant, Hwy. 39 near jct. with Hwy. 78, sec. 3, [T4N, R6E,] *H. Greene & J. Curtis s.n.,* 7 Aug. 1948 (WIS). WAUSHARA CO.: sec. 30, T18N, R9E, *R. Pochmann s.n ,* 7 Sep 1957 (WIS).

Kruschke (1946, p. 289) cited this variety from two localities along the western edge of Wisconsin. The present collections indicate a more widespread distribution eastward toward the center of the state.

Two collections which have been referred to in the past to *Onosmodium hispidissimum* I have reidentified as *O. molle* var. *occidentale*: the Crawford Co. voucher, which was listed by Hartley (1966, p. 70), and the Rock Co. specimen, which was cited by Musselman et al. (Mich. Bot. 10: 183. 1971). *O. molle* var. *hispidissimum* remains on the list of Rock Co.'s flora since it has been collected there at Beloit (*G. Olds s.n.* in 1895, BELC) and at Carver's Rock (*S. Wadmond 3050* in 1906, MIN). Having been annotated by Kruschke in 1940, Wadmond's specimen must be the voucher for the Walworth Co. record in Kruschke (1946, p. 284).

Pulmonaria officinalis L.

[RUSK CO.:] one plant, bank of spring-fed streamlet, Jump River at Shaw's Eddy, 6 mi. NE of Jump River, [sec. 34, T34N, R3W,] *J. Flanagan 1,* 7 May 1972 (UWSP).

This European species has not been reported previously as an escape in Wisconsin, nor is it included as occurring within the ranges of the manuals by Fernald (1950), Gleason (1952), or Gleason and Cronquist (1963). The omission of *Pulmonaria* from Johnston's discussion (1924) implies that no report existed from the Americas previous to that time, and a check of additional floras and five major journals has not yielded a single reference to that genus (except for western species now taken to be members of *Mertensia*).

The occurrence of only a single plant at the above site, which is at some distance from cultivated ground, apparently grants the species valid claim for admission to the flora. It is probably cultivated in old-fashioned gardens like *Borago officinalis, Cynoglossum amabile, Heliotropium arborescens,* and *Symphytum officinale,* but it can scarcely be considered as an established weed.

I am referring this specimen to *Pulmonaria officinalis* with some hesitation, because its rosette leaves are not at all mature; it may be a plant of *P. saccharata.* As treated by Merxmüller and Sauer in Tutin et al. (1972, pp. 100-102), *Pulmonaria* consists of a complex group of species in which there is much intergradation and overlap.

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THE VEGETATION OF A WHITE-CEDAR SWAMP IN SOUTHWESTERN MICHIGAN

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Southeastern Michigan bogs and swamplands have been studied more extensively than those in the southwestern part of the state. Except for recent work by Brewer (1966) the only published works on lowlands in this area of the state were by Davis (1907) and Livingston (1902). This study should help fill that void, especially in Kent County, and present some historical and vegetational data which show some successional trends for lowland swamps in southwestern Michigan.

THE STUDY AREA

The study area is located in Byron Township, Kent County, on the west side of U.S. 131 about halfway between 76th and 84th Streets, in the NW¼ of the SE¼ of Sect. 13, R12W, T5N. The area is roughly 1/4 mile long and 1/8 mile wide.

The soil is Carlisle muck. According to Wildermuth and Kraft (1926), this muck is decayed vegetational matter which has a coarse, black surface layer from six to eight inches thick. Under this is a fine, smooth disintegrated layer which can be from 2 to 10 feet thick. The muck in this swamp was seven feet deep. The muck was slightly alkaline, tested colorimetrically.

Carlisle muck usually rests on gray sand or gravel. In this area, the muck rests on sand. Soils of the surrounding areas are sands and loam (Wildermuth & Kraft, 1926). Davis (1907) connected the West Carlisle muck area with the Byron Center muck area to the southwest on his map of the original swamp areas of the Lower Peninsula. Since this whole area is very flat, it is possible that these areas were also part of the "Green Lake" mentioned by Livingston (1902).

The swamp was disturbed in 1961 when the U.S. 131 expressway was built (Fig. 1). The expressway cut through the eastern section of the swamp and separated a tamarack-cedar portion to the east from the rest of the swamp. The margins along the expressway are now primarily composed of willow, quaking aspen, upland species of sumac, and red-osier and gray dogwoods.

Another disturbance has recently taken place in the swamp. Parts of the western and northern sections were once occupied by elms. These have died from Dutch elm disease and are now being replaced by green ash, red maple and yellow birch saplings.

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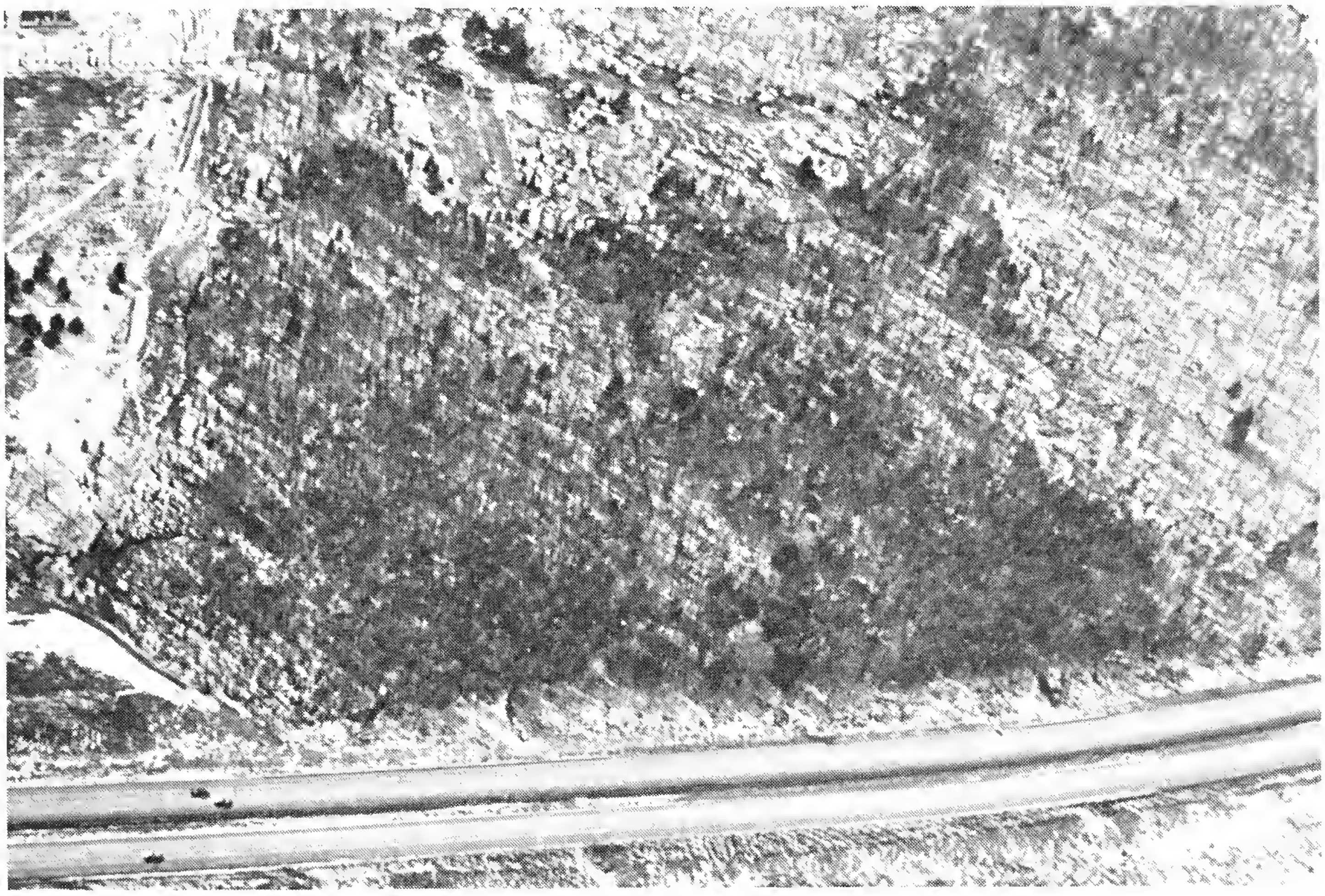

Fig. 1. Aerial view of the study area showing the expressway running north-south through the eastern portion of the swamp (north is to the right). The photograph was taken during the winter so that all foliated trees are either cedar, hemlock, or white pine.

The northern half of the swamp is quite wet, while the southern half is dry with scattered wet patches. Two creeks originate within the swamp boundaries. These creeks join on the western edge and flow into one of the many drainage ditches in the section. Eventually this water enters Buck Creek and then the Grand River.

HISTORY OF THE SURROUNDING AREA

According to early records, Byron Township was heavily timbered with hardwoods and several sections of pine. A large tamarack swamp extended from within two miles of the NE corner of the township across the County line in a SW direction. The township was shunned because of heavy timber and swamps until 1835 when it was settled by Nathan Boynton (see Belden, 1876, and Chapman, 1881).

Later a small town sprang up on the railroad north of the muck region. The village of West Carlisle was incorporated in 1884 with a population of 35. In later years the population grew to 100 people as the village became a truck-farming center. The only remains of the village at present are a general store and a meeting hall.

According to Hilda Bouma (personal communication) the swamp tract was cleared before 1899 by a local individual rather than a lumber company. Mrs. Art Hill (personal communication) said she could remember the farmers still taking logs from this general area to Grand Rapids at the turn of the century in the winter by sleigh. The logs would then be floated down the Grand River to Grand Haven to be cut. Based on ages (determined by increment borings) of hemlocks and birches which have invaded since the logging, the swamp may have been logged before 1875.

The muck areas were cleared and drained for truck-farming. There are still shallow ditches criss-crossing the greater portion of the Carlisle muck region. The only area spared from agriculture was the present stand of cedar which was evidently too wet to be used for farming even after lowering of Buck Creek. This truck-farming venture never grew very large in the immediate area and was terminated over 50 years ago.

It should be noted that the only other sizable expanse of utilized Carlisle muck nearby was just south of Byron Center. That area of several thousand acres was used extensively for truck-farming until 40 to 50 years ago.

METHODS

The area was sampled in 1967 during March, May, and June. The point-centered quarter method (Cottam & Curtis, 1956) was employed for sampling the canopy vegetation. Twenty-two points were used along three transects. Trees which were more than one inch in diameter at breast height (DBH) were included. A few increment borings were taken to determine ages of representative trees.

The woody understory vegetation was sampled by a series of 118 square meter quadrats. A subjective method along with some random elements was used for taking these samples. The canopy was observed and a point selected. Then using random numbers, the number of steps (north) to start taking contiguous quadrats was determined. The sampling was continued until that certain type of canopy (cedar, hemlock, or birch) disappeared.

The herbs were sampled in the same manner as the woody understory vegetation except that fewer quadrats were taken in each series. A total of 36 square meters was sampled. Plant names were taken from Gleason and Cronquist (1963).

COMPOSITION OF THE VEGETATION

The swamp was dominated by white-cedar (*Thuja occidentalis*), hereafter referred to as cedar (Table 1). The next important species, ranked by importance values (Curtis & McIntosh, 1950), were eastern hemlock (*Tsuga canadensis*), yellow birch (*Betula lutea*), white pine (*Pinus strobus*), red maple (*Acer rubrum*), green ash (*Fraxinus pennsylvanica*), blue-beech (*Carpinus caroliniana*), and American elm (*Ulmus americana*). Curtis's work (1959) in Wisconsin with northern wet-mesic forests showed cedar having an importance value of 91 and hemlock, 40. Other species listed by Curtis did not correspond to those found in this study. According to Brewer (1966) yellow birch, the other dominant species here, is an abundant tree in mixed forest bogs of the Kalamazoo area.

Although cedar was the most frequently encountered tree, it was not the largest. Yellow birches were the largest trees growing in the swamp (largest birch in the sample was 25.3 in. dbh; hemlock, 11.5 in.; and cedar, 10.1 in). Many of the birch trees are growing out of old cedar stumps remaining from logging operations of the 1800's (Fig. 2). A small sample of borings showed most birches were about 65 years old.

TABLE 1. Characteristics of the tree stratum (1 inch dbh and larger) of the cedar swamp.

Character	White Cedar	Eastern Hemlock	Yellow Birch	Green Ash	Red Maple	White Pine	Blue Beech	Am. Elm	All Trees
Density (trees/acre)	196	61	51	19	28	28	19	5	410.3
Mean dbh (in.)	5.2	7.4	9.6	6.6	4.5	7.8	3.5	8.7	–
Basal area (sq. ft./acre)	29.4	18.2	25.7	4.5	3.1	9.2	1.1	2	94.4
Relative frequency	35.8	17.0	13.2	7.6	11.3	9.4	3.8	1.9	–
Importance values	117	51	53	17	21	26	10	5	–

Fig. 2. A yellow birch tree growing out of an old rotted cedar stump left from logging operations of the late 1800's.

The density of this cedar swamp (for trees 3 inches dbh or more) was 382 trees/acre. Brewer (1966) calculated the densities for a tamarack bog and a mixed bog forest as 419 and 347 trees/acre respectively. It appears that the cedar swamp density was intermediate between those of the tamarack bog and the mixed forest bog. However, the total basal area of the cedar swamp was nearer that of the mixed forest bog. The birches and ashes on this tract contributed considerably to the basal area even though they were not very abundant.

A surprising vegetational deviation of this cedar swamp was the composition of the primary understory (Table 2). It consisted of spicebush (*Lindera benzoin*), rather than speckled alder (*Alnus rugosa*) found in more northern cedar swamps (Conway, 1949; Curtis, 1946; Curtis, 1959; Gates, 1942; Heinselman, 1970; Martin, 1959). Brewer (1966) found a spicebush understory in a mixed bog forest near Kalamazoo, Michigan.

TABLE 2. Number of stems per square meter and percent frequency of the woody understory plants under 1 inch dbh. The stem counts are also divided into the three types of canopies which were present.

Species	All Canopies	Birch Canopy	Cedar Canopy	Hemlock Canopy	Percent Frequency
Lindera benzoin	2.02	2.15	1.90	1.73	61.9
Taxus canadensis	0.32	0	0.08	1.59	7.6
Fraxinus pennsylvanica	0.15	0.20	0.05	0.23	10.2
Euonymus obovatus	0.28	0.35	0.10	0	8.5
Acer rubrum	0.29	0.75	0.05	0	10.2

Another plant usually associated with lowland deciduous forests which was found growing on this tract was running-strawberry (*Euonymus obovatus*). It appeared to grow under birch trees more frequently than under cedar or hemlock. (Table 2). The greater quantity of light under the birch trees may be an important factor.

American yew (*Taxus canadensis*) was present in the wetter regions of the swamp under both cedar and hemlock canopies. The yew was also observed in the dead elm portions in the northwest section of the swamp. Yew was not present under birches perhaps because these were drier areas.

The swamp floor vegetation was composed mainly of Canada mayflower (*Maianthemum canadense*), skunk-cabbage (*Symplocarpus foetidus*), and wild sarsaparilla (*Aralia nudicaulis*). These and the other plants composing the floor vegetation (Table 3) appear to be a blend of both southern and northern lowland forest species. Most of the characteristically peatland species are those found on minerotrophic sites (Heinselman, 1970).

TABLE 3. Percent frequency of species in the herbaceous vegetation inclusive only of those species with a percent frequency of 10 or more.

Species	Percent Frequency	Species	Percent Frequency
Maianthemum canadense	64	Galium spp.	16
Symplocarpus foetidus	53	Phlox sp.	16
Aralia nudicaulis	48	Anemonella thalictroides	14
Hepatica americana	39	Trientalis borealis	13
Arisaema triphyllum	39	Geranium maculatum	13
Cystopteris bulbifera	32	Onoclea sensibilis	13
Osmunda cinnamomea	23	Trillium sp.	11
Viola spp.	19	Coptis trifolia	10
Mitchella repens	17	Rubus pubescens	10
Polygonatum pubescens	16	Urtica sp.	10

SPECULATIONS ON VEGETATIONAL SUCCESSION

Martin (1959) states that in the hydrosere of Ontario an open bog is invaded by black spruce (*Picea mariana*). Then the bog is usually invaded by cedar, which becomes co-dominant with spruce. Perhaps this is what happened to the Carlisle muck area. A large lake was formed, which covered a long area from Carlisle southwest to Byron Center, after glacial recession. Gradually the two areas became isolated and natural succession from lake to forest took place. There are no present records of any spruce in the area, but it was still present at Saddlebag Swamp east of Grand Rapids and about 15 miles northeast of the study area in the latter part of the Nineteenth Century (Livingston, 1902).

A sample of 15 cedar stumps left from the lumbering operations ranged in diameter from 18 to 54 inches (at stump height) with a mean of 27 inches. Based on a graph constructed by Harlow (1927), the largest trees would have been about 450 years old.

When drainage ditches were built in the truck-farming area, this cedar area must have become much drier, and it became possible for hemlock to invade. Older hemlocks in the swamp were found to be about 70 years old. Hemlocks on the northern sand ridge were nearly 100 years old and were probably small trees when the area was lumbered.

The disturbed area along the expressway seems to be following a succession given by Gates (1942). He showed a succession either from bramble through aspen to cedar or from *Calamagrostis* through *Salix-Cornus* thickets to cedar. The expressway edge is presently aspen and willow with some dogwood and sumac. A mixed forest instead of cedar will probably invade this edge area. In the dead elm areas, willow-dogwood thickets are present but saplings of species characteristic of lowland deciduous forests are also present. From this evidence, it seems doubtful that the dead elm portion will return to a cedar-dominated swamp.

A recent visit to the study area, on 28 December 1974, revealed that most of the cedars in the swamp have died since 1967. The only saplings present in the dead elm portion were still the birch, ash, and maple. Therefore, it appears that the southern mixed forest species are invading the remaining cedar swamps of southwestern Michigan. Such species already contribute to the woody understory flora and will probably eventually replace all the cedars as they die and open the forest canopy.

SUMMARY

The woody and herbaceous vegetation of a cedar swamp in southern Kent County, Michigan, was sampled in 1967. The swamp was dominated by white-cedar with eastern hemlock and yellow birch being the other important canopy species. The understory woody vegetation was primarily spicebush, American yew, and ash; speckled alder, common in cedar swamps further north, was not present in the sample. The cedars are now (1974) dying and are apparently being replaced by a mixed forest of hemlock, yellow birch, green ash, and red maple.

ACKNOWLEDGMENTS

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RECENT WISCONSIN RECORDS FOR SOME INTERESTING VASCULAR PLANTS IN THE WESTERN GREAT LAKES REGION

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From time to time field botanists with a particular interest in the flora of Wisconsin and the Great Lakes region have published information on the occurrence and distribution of elements of the flora (e.g., Case, 1964; Freckman, 1972; Guire & Voss, 1963), new records and range extensions of taxa within the state (e.g., Cochrane, 1975; Fassett, 1934; Harriman, 1971) and treatments of complex groups (e.g., Fassett, 1951; Fuller, 1933; Shinners, 1941). In addition, the Preliminary Reports on the Flora of Wisconsin series were initiated by Professor Norman C. Fassett in 1929 and continue under the guidance of Professor Hugh H. Iltis at the University of Wisconsin–Madison. There are, however, still many opportunities for the student and professional to document and investigate problems in our ever-changing flora. Many areas of the state, for example, are poorly known floristically. The Northern Highland Province in north-central Wisconsin, the Lake Superior Lowlands and Apostle Islands, northeastern Wisconsin (especially Florence County), as well as other infrequently traveled spots throughout the state need to be collected.

Largely as a result of man's severe modification of the landscape, many plants such as *Agrimonia parviflora* (Mason & Iltis, 1959; Musselman et al., 1971), *Butomus umbellatus, Cirsium palustre* (Johnson & Iltis, 1963), *Epipactus helleborine, Geum vernum, Helenium flexuosum* (Mickelson & Iltis, 1966), and *Lycopus asper,* to name just a few, have become established relatively recently in the state. Others seem to be expanding their range, and it is useful to document the urban invaders, halophytes along our heavily salted highways, and the pioneers of cinder and gravel rights-of-way. In addition, it is becoming more important than ever before to reexamine the old collection sites of some of the rare and uncommon native plants originally discovered in the 1860's through 1930's to document their existence or loss so that future published range maps can reflect their current distribution in relation to their former range.

New directions and unexplored areas of endeavor have brought about an awareness of the need and rekindled interest in seeing the completion of a comprehensive treatment of the flora of Wisconsin. The authors, in their capacity as botanists for the Scientific Areas Preservation Council, Wisconsin

Department of Natural Resources, have traveled extensively throughout the state to locate, evaluate, and delineate outstanding natural areas exhibiting characteristics of presettlement plant community types. Their activities have become more systematic and intense in the last few years as data on the regional flora and remnant natural areas have accumulated. The rapid increase in prairie preservation and restoration has focused attention on locating prairie remnants, managing them for long term preservation, and using them as seed collection sites. There is also a growing concern for the vanishing native species and for the few remaining whole plant-animal communities which has culminated in the passage of initial federal and state legislation dealing with threatened and endangered species.

It is hoped that reporting recent discoveries and significant range extensions will stimulate new interest in Wisconsin's floristics and at the same time disseminate information to the numerous public and private herbaria in the region. All of the taxa featured in this report are represented by reference collections maintained in the herbarium of the first author, except where otherwise cited by standard herbarium designations (Holmgren & Keuken, 1974), and anyone wishing to examine the specimens is welcome to do so.

Locations of the counties mentioned in the text may be found in Fassett (1951, p. 100) for Wisconsin counties, or in Case (1964, p. 110) for all counties in the western Great Lakes region.

Anemone caroliniana Walt.

The distinctive *Anemone caroliniana* is a widespread western species of dry prairies and barrens extending eastward in the midwest to a single county in west-central Indiana (Deam, 1940). It is rare in central and northern Illinois (Jones & Fuller, 1955), occurs in a narrow band across southern Minnesota (Morley, 1969), occurs infrequently across the northern half of Iowa (Fitzpatrick & Fitzpatrick, 1901), and reaches its eastern contiguous limit in Wisconsin in the far western prairies (Fassett, 1947).

Four collections are on file at WIS. The counties in which they were collected and the date of collection are: LaCrosse, 1888; Eau Claire, 1924; Pierce, 1935 and 1936. Four recent collections (RIV and OSH) from Pierce County near River Falls were made between 1970 and 1973, while a 1970 collection (RIV) made near Menomonie is the first record for Dunn County.

A new station for *A. caroliniana* has been found in St. Croix County (T29N, R20W, Section 36; Tans & Read 557, June 4, 1974), where it occupies a xeric gravel prairie with a western exposure above Lake St. Croix in association with *Andropogon scoparius, Bouteloua hirsuta, Chrysopsis villosa* and *Liatris aspera.* Additional associates are *Liatris punctata, Penstemon grandiflorus, Delphinium virescens,* and *Tradescantia bracteata,* all of which are entirely or nearly restricted to xeric habitats in the northwestern region of the state.

It is noteworthy that nearly all of the steep gravel banks along the St. Croix River in St. Croix County have been overgrown with a thin forest, altered by human development or grazed, except at this one site, which is the location where an abandoned railroad right-of-way (r.o.w.) descends to the river valley floor. It is probable that during construction of the r.o.w. many years ago, the area's natural characteristics were sufficiently altered, so as to set back natural succession and thus prevent growth of woody plants, but favoring colonization by the native, xeric pioneers inhabiting adjacent gravel prairies.

Unfortunately, less than ten individuals of *A. caroliniana* were observed close to the summit of the gravel embankment. Since the railroad r.o.w. has been abandoned, a portion of the gravel slope has been planted to *Pinus resinosa* by a private owner. Unless measures are undertaken to preserve the area's natural integrity, the long term maintenance of one of the few known sites for *A. caroliniana* is doubtful.

Aster furcatus Burgess

This distinctive aster has a very limited total distribution (Michigan [Van Fassen, 1971; introduced?], Indiana, Illinois, Iowa [Thorne, 1953], southeastern Missouri, and eastern Wisconsin), and by the reports in most state or regional floras containing the species, it is a rather rare plant. For example Deam (1940) states, "This species is evidently very rare in this state," while Steyermark (1963) notes it as "one of the rarest asters in Missouri." However, as Swink (1974) notes in several northern Illinois localities, a population may be extensive at a particular site.

In Wisconsin *A. furcatus* has been collected sporadically in the eastern counties–Kenosha (Swink, 1974) northward to Kewaunee (Benke, 1936)–since 1874, with most of the collections coming from Milwaukee County, which is of course now highly urbanized. A July, 1966, collection (N. A. Harriman 1195, OSH) from a railroad right-of-way south of Oshkosh (Winnebago County) and a 1970 collection from a park east of Fond du Lac (J. Hansen 010, OSH) represent more recent northwestward range extensions in Wisconsin, though likely of introduced origin.

The discovery of forked aster in Walworth County by R. H. Read (s.n.) in 1971 represents the only other collection to our knowledge from a new station in the state since 1941 (which was from Milwaukee County, in WIS). Unlike the 1966 Winnebago County collection, this most recent collection comes from a minimally disturbed woodland. This diversity in the quality of habitats from which the few collections of *Aster furcatus* have been taken–rich woods and woodland edges to railroad rights-of-way–is somewhat disconcerting to the botanist who would like to think (or hope) that all rare plants should be found in the most pristine habitats. Clearly, much needs to be learned about the life history of this elusive regional endemic.

At the new Walworth County site forked aster grows in shaded ravines and on the damp edges of a rich, dry oak-hickory woods which slopes down to the edge of Lauderdale Lake (T4N, R16E, Section 34). Growing in the same woods, often in close association with the aster, is the very uncommon upland boneset, *Eupatorium sessilifolium* L. var. *brittonianum* Porter. (Note that the occurrence of both here is cited by Swink, 1974.) Unfortunately Lauderdale Lake is a highly developed recreational area and this high-quality woods is threatened by home construction, although it was still intact in late 1974.

An additional station for *Eupatorium sessilifolium* var. *brittonianum* was found in a similar habitat in Walworth County (morainal, wooded hillside near

Whitewater Lake, T4N, R15E, Section 35) by W. Tans (Tans 1130) on September 27, 1974. It is interesting to note that practically all of the previously known sites for upland boneset in Wisconsin are in, or a few miles from, the "driftless area" (Johnson & Iltis, 1963).

Astragalus crassicarpus Nutt.

Astragalus crassicarpus (var. *crassicarpus*), prairie plum, is a legume native to far western Wisconsin in Pierce and St. Croix Counties (Fassett, 1939, as *A. caryocarpus* Ker). It is a species of the Great Plains and ranges from Texas into southern Canada (Barneby, 1964). Only seven specimens are on file at WIS and those were collected in the 1930's. However, several more recent records from Pierce County are on file at RIV (Evans 28, 21 May 1971, T27N, R18W, Section 5; Hallberg 56, 12 May 1973, T27N, R18W, Section 8; Richardson s.n., 12 May 1974, T27N, R19W, Section 11; Richardson 3099, 6 May 1970, T27N, R19W, Section 2; Dueholm s.n., 8 May 1974, T27N, R18W, Section 17) all from sites within a three-mile radius of River Falls. The last two collections listed are from populations we saw in the summer of 1974.

An additional station in Pierce County from an excellent quality prairie remnant was discovered 28 June 1974, by W. Tans and K. Lange (T25N, R18W, Section 28; Tans 654). While not county records, this new station and the extant populations near River Falls are reported here to reaffirm the existence in Wisconsin (at least in Pierce County) of this species, often an indicator of undisturbed prairie. The last-mentioned station above especially exemplifies this quality, for here, near Hager City in a good-sized dry, limey prairie, *A. crassicarpus* occurs with such rare and uncommon species of Wisconsin as *Artemisia frigida, Cirsium pumilum* ssp. *hillii,* and *Psoralea esculenta* in addition to numerous other prairie associates. In view of the several thousand acres of native prairie in presettlement times in the Pierce and St. Croix County region, this undisturbed site is a significant natural area.

Carduus nutans L.

Carduus nutans, commonly known as nodding thistle or musk thistle, has large solitary heads on long naked peduncles; these, combined with its height which frequently reaches two meters, render it readily identified from a considerable distance particularly when it is in flower from June through August. It was first collected in the state in Waukesha County in 1947, and when its range was mapped by Johnson and Iltis (1963), it was known from Green, Rock, Walworth, Jefferson, Milwaukee, and Waukesha Counties in southeastern Wisconsin. In 1964 it was collected in Kenosha County. *C. nutans* has spread westward across southern Wisconsin as evidenced by recent collections from Lafayette County in 1972, Grant County in 1973 and Richland County in 1974 (WIS collections).

Carduus nutans was apparently introduced late in the 1880's on the east coast of North America (Stuckey & Forsyth, 1971) and has spread methodically westward. It was first collected in Indiana, Ohio, and Iowa in 1924, 1925, and 1937, respectively (Stuckey & Forsyth, 1971), and initially in Illinois in 1930 (Wunderlin, 1969).

Two new and somewhat disjunct stations for *C. nutans* were discovered in 1974 in Pierce County (T26N, R19W, section 32; Tans 653, June 28,

1974) and St. Croix County (T29N, R20W, Section 36; Tans 678, June 30, 1974) about 150 miles northwest of the Grant County site. The Pierce County site is an open, heavily grazed *Poa* pasture within one-half mile of the Mississippi River, while at the second site, *C. nutans* had invaded an abandoned hay field grown over by brome grass. This illustrates the aggressive capabilities of *C. nutans* propagules. Although only one plant was observed at each location, it is probable that a series of intermediate sites up the Mississippi and St. Croix River valleys exists. *C. nutans* may eventually invade disturbed habitats in Crawford and Vernon Counties, if it has not done so already, via the Wisconsin and Kickapoo River valleys.

The region described above where the species is known to exist in Wisconsin is underlain by calcareous bedrock (see the Wisconsin geological map on p. 93 in Fassett, 1951) and northwest of the "driftless area" a mantle of calcareous till covers the bedrock offering a preferred substrate for *C. nutans.* Stuckey and Forsyth (1971) observed that the distribution of *C. nutans* in Ohio was limited and occurred where limestone or dolomite bedrock was at or near the surface.

It is logical to conclude that musk thistle, a noxious weed in southeastern Wisconsin, will expand its range and frequency of occurrence in southwestern, western, and northwestern Wisconsin where isolated individuals have already been collected. It is noteworthy that all of the currently known sites for *C. nutans* are south of the tension zone identified by Curtis (1959; see map on p. 20). However, W. Tans has recorded sighting *C. nutans* in southwestern Ozaukee and southeastern Washington Counties; thus it appears to be also spreading northward into the tension zone. It is not unreasonable to suspect that this vigorous colonizer of disturbed open sites will continue to slowly spread northward in eastern Wisconsin, for the till and bedrock substrates there are calcareous.

Carex concinna R. Br.

Unknown in Wisconsin until recently (Zimmerman 3710, June 12 & 13, 1954; WIS) this boreal species of *Carex* ranges across northern North America from Newfoundland to the Yukon (Mackenzie, 1935), coming south in the midwest to northern Michigan, where it is very local and known from three counties and Drummond Island (Voss, 1972) [plus Alpena County, Schoolcraft County, and Bois Blanc Island since publication; MICH records], and the Door Peninsula in Wisconsin. There it was most recently collected by us (Read & Tans 58, June 25, 1973) from a mossy and somewhat dry, low Niagara dolomite ledge, partially shaded by a conifer forest of *Abies balsamea, Thuja occidentalis* and *Picea glauca* (T31N, R28E, Section 24) within a quarter mile of Lake Michigan. This is the second station for *C. concinna* in Door County. Known locally as Marshall's Point, the area encompasses some 450 acres of pristine upland conifer forest on the south end of a dolomite headland projecting into Lake Michigan.

The boreal forest community on the Door Peninsula as mapped by the Wisconsin Geological and Natural History Survey (1965) is substantially disjunct from the main body of boreal forest in the Lake Superior region of northwestern Wisconsin; thus it is not surprising that Marshall's Point possesses an outstanding flora. *Festuca occidentalis* Hook., known in Wisconsin only from Door County (Fassett, 1951), was also collected by us in the Marshall's Point boreal forest. *F. occidentalis* is disjunct in the Great Lakes region from the western and northwestern states and adjacent Canada (Hitchcock, 1951).

Carex folliculata L.

Carex folliculata is a robust, handsome, and readily distinguishable sedge ranging westward to Wisconsin from Newfoundland and southward to the District of Columbia and Indiana; it also occurs in the Appalachian Mountains to North Carolina and Tennessee (Mackenzie, 1935). In the midwest it is rare. It occurs in five counties in northeastern Ohio (Braun, 1967), two counties in the dune area in northwestern Indiana (Deam, 1940), and is now extinct in Illinois (Jones & Fuller, 1955). According to Voss (1972), *C. folliculata* is very uncommon and local in Michigan, and it occurs primarily in the counties bordering the east side of Lake Michigan.

In Wisconsin, the distribution of *C. folliculata* is very restricted, with known stations in Jackson, Juneau, and Monroe Counties in the west-central portion of the state (WIS records). A new county record is from Mentor Marsh in Clark County (T24N, R4W, Section 1; Kubisiak s.n., August 20, 1974).

The following data on two additional sites for *C. folliculata,* although not new county records, are presented to document existing populations and habitat of this rare sedge. The first is within Camp McCoy Military Reservation, Monroe County (T19N, R3W, Section 14; Tans s.n., July 6, 1972); the second is in Forest Crop Land owned by Jackson County (T20N, R1W, Section 28; Tans 127, August 3, 1973). The Camp McCoy site is a *Pinus strobus–Acer rubrum* swamp forest with the tall shrubs *Alnus rugosa, Ilex verticillata,* and *Nemopanthus mucronata* throughout the swamp. *Sphagnum* moss forms hummocks on the forest floor, and in the wet, mucky depressions the cespitose *C. folliculata* is found.

At the Jackson County site, *C. folliculata* grows in the small and wet mucky drainages tributary to Jay Creek in an area forested with *Pinus strobus* and *Acer rubrum.* At both sites common herbaceous associates are *Carex crinita, C. intumescens, Clintonia borealis, Cornus canadensis, Coptis trifolia, Dryopteris spinulosa, Symplocarpus foetidus,* and *Trientalis borealis.*

Carex michauxiana Boeckl.

According to the distribution given by Mackenzie (1935), *Carex michauxiana* ranges from Newfoundland to Ontario and southward to New Hampshire, New York, Pennsylvania, and Michigan. In the latter state, it is known from seven counties in the Upper Peninsula plus Isle Royale (Voss, 1972). *C. michauxiana* in Wisconsin is even more localized in its distribution. Formerly known from a single locality in Wisconsin on the Apostle Islands (Stockton Island, WIS records) off the Bayfield Peninsula, *C. michauxiana* was collected by us for the first time on the mainland at Raspberry Bay Bog (T51N, R4W, Section 2; Tans & Read 879, July 31, 1974). Raspberry Bay Bog, situated at the mouth of the Raspberry River on Lake Superior, lies behind a low, sand baymouth bar. It is a sedge-*Sphagnum* bog, and in addition to *C. michauxiana,* fifteen other species of *Carex* were observed there in July, 1974 with these other bog plants: *Cladium mariscoides, Drosera intermedia, D. rotundifolia, Habenaria clavellata, Utricularia cornuta, U. intermedia, Scheuchzeria palustris,* and *Vaccinium oxycoccos.*

Many of these same associates occur with *C. michauxiana* at the Stockton Island Bog (Ashland County: T51N, R2W, Section 1; Tans 937, August 11, 1974) which was field inspected by W. Tans to verify the presence of the rare sedge. Large populations of *C. michauxiana* occur in both bogs.

Chaerophyllum procumbens (L.) Crantz

Chaerophyllum procumbens, wild chervil, is an annual in the parsley family fairly widely distributed across the eastern half of the United States, the range of which is given by Mathias and Constance (1944) as New York and Ontario to Virginia and west to Iowa, Kansas, and Arkansas. In the upper midwest, wild chervil occurs primarily in the southern two-thirds of Indiana (Deam, 1940), southern Michigan (Gleason & Cronquist, 1963), and most of Illinois {but less common northward, although known from Winnebago (Jones & Fuller, 1955), and Lake and Boone Counties (Swink, 1974) along the state's northern border]. Musselman et al. (1971) give its total range in Wisconsin as the Sugar River bottoms in Rock County, where it barely enters the state from Winnebago County, Illinois, to the south.

A new station for *C. procumbens* in Grant County was discovered by Mr. Bruce Hansen with the first author in 1974 (Hansen 2535 [WIS]; Tans 473, both on May 20, 1974). It was commonly observed at the interface of the floodplain and upland forest along the Platte River (T3N, R2W, Section 18) which empties into the Mississippi River in southwestern Grant County. The site was disturbed by moderately intense grazing, although with no apparent detriment to *Chaerophyllum.* This plant should be sought along the Mississippi River valley to the south in Jo Daviess County, Illinois.

Eleocharis rostellata Torr.

Few species of spike-rushes in Wisconsin are as distinctive or as rare as the beaked spike-rush, *Eleocharis rostellata.* The species has a widespread distribution (seacoast of Nova Scotia southward to Florida, inland across the continent from Ontario to British Columbia and south into the Caribbean islands, and in the Andes Mountains of South America [Svenson, 1957]) but inland sites away from the saline coastal marshes are much less common. In Illinois, for example, the plant was known from only one old collection (Jones & Fuller, 1955) and was presumed extirpated from the state until a 1970 collection was made by Professor Galen Smith in Lake County (Swink, 1974).

Likewise, in Wisconsin *E. rostellata* was known from only one site in Racine County up to 1953 (Greene, 1953). However, the number of new localities found since then (fully half of them in the summer of 1974 alone) has quadrupled the number of collections in Wisconsin. It is now known from Walworth (Swink, 1974), Waukesha (Tans 988, August 29, 1974), Kenosha (Swink, 1974), and Racine counties.

The Waukesha County location is particularly worthy of mention. Here around the edges of Ottawa Lake (T6N, R17E, Section 34), on the broad, wet marly flats beaked spike-rush covers several acres, arching and rooting at the tips of sterile culms in its characteristic manner. Associated species seen in late August and September include a diverse group of calciphiles in what closely approximates the fen community described by Curtis (1959): *Aster junciformis, Gentiana procera, Lobelia kalmii, Lysimachia quadriflora, Parnassia glauca, Pedicularis lanceolata, Potentilla fruticosa, Rhynchospora capillacea, Spiranthes cernua,* and *Solidago ohioensis.* Such rich habitats are exceedingly rare in Wisconsin and the site is being recommended as a State Scientific Area (it is, fortunately, owned by the Department of Natural Resources).

Lespedeza leptostachya Engelm.

Lespedeza leptostachya, prairie bush-clover, is an upland prairie plant endemic to the upper Mississippi River valley, originally known from central Minnesota south to northwestern Iowa and northeastern Illinois (Clewell, 1966; see the range map in Mickelson & Iltis, 1966). In Wisconsin it had been collected four times in the period 1860-1880, but not since then despite an intensive search by Fassett (1939). He concluded that *L. leptostachya* was probably extinct in the state.

It was with considerable interest that a population of more than thirty plants was discovered in southern Rock County (T2N, R12E, Section 25; Tans 184, September 3, 1969) (cited in Musselman et al., 1971) on a moderately disturbed dry prairie remnant in what was once the several thousand acre Rock Prairie. The site is underlain by pre-Wisconsin glacial drift with a rolling topography. Prairie bush-clover occurs near the base of one of the low ridges in dark brown soil less severely eroded than that on the ridge top. Numerous other native dry prairie species occupy the remnant although *Poa* and other weedy invaders are abundant.

Strangely enough, this is not the only site where *Lespedeza* has been recently discovered. At a nearly identical site in Dane County (Chapman Prairie, T8N, R9E, Section 11) several specimens of *L. leptostachya* (R. Ellarson, s.n., September 17, 1970; WIS) were found on the lower *Poa*-invaded slope of a dry moraine prairie. An additional collection comes from the Schluckebier Prairie, Sauk County (T9N, R6E, Section 4; Threlfall s.n., August 30, 1971; WIS). Whether these sites represent remnant populations clinging to their native habitats or invading populations is not known; however, the Schluckebier Prairie is known to have had a history of plowing and grazing.

Littorella americana Fern.

Few plants in eastern North America have been so misunderstood well into the 20th century as this peculiar aquatic member of the plantain family (see Voss, 1965, and Tessene, 1968, for a review and reasons of the differing opinions). While it has been overstated that *Littorella* is "one of the rarest plants of the North American flora" (Fernald, 1918)—the plant is reported by Bassett (1973) as being common in Nova Scotia and other parts of the Maritime Provinces of Canada—our own recent field experience in northern Wisconsin lakes has not shown it to be "a characteristic and abundant plant in many lakes of northern Wisconsin," as stated by Fassett (1934).

Indeed, in the neighboring states of Michigan and Minnesota the species was not found until 1964 in the former (Voss, 1965), and only one 1886 collection was known prior to 1953 in the latter (Lakela, 1958). In Wisconsin Tessene (1968) has recently documented *Littorella* from seven lakes in five counties while Fassett (1939), who usually collected assiduously, lists its occurrence in 13 lakes in the same five counties.

In the summer and early fall of 1974, we made a vegetation survey of highly oligotrophic lakes in Vilas County. Many of the lakes we inventoried were those sampled by Fassett (1930) by means of a surface dredge. Despite our more direct visual methods of snorkel or SCUBA inspection of the bottom flora, only Firefly Lake (T41N, R7E, Section 28), also known as Weber Lake, was found to contain sterile *Littorella.*

Firefly Lake is an extremely infertile lake with a pure sand bottom overlain by up to 5 mm of dark organic material in the littoral zone. The water is slightly acidic, soft [May, 1961, methyl orange alkalinity of 3 ppm (Black et al., 1963)] and highly transparent. All plants were completely submerged and formed a dense clone in ca. 0.6 m of water. Among the lakes we surveyed, a unique assemblage of interesting aquatic species occurs to depths of 3 m in Firefly Lake. With the *Littorella* these additional aquatics were observed: *Elatine minima, Eriocaulon septangulare, Gratiola aurea* f. *pusilla, Isoëtes muricata, Isoëtes macrospora, Juncus pelocarpus, Lobelia dortmanna, Myriophyllum tenellum,* and *Sparganium angustifolium.*

It is interesting that while the vegetation of Firefly and adjacent lakes has been extensively studied by Fassett (1930), Wilson (1935), and Potzger & Van Engel (1942), our discovery of *Littorella* here (Tans & Read 849, August 2, 1974) is new (yet we could not relocate the species as reported by Fassett in nearby Crystal Lake). All previous studies relied on visual identification and dredging of plants from a boat, the success of which is dependent largely on weather conditions; our use of SCUBA and snorkel diving avoids such dependence and makes qualitative observations much more direct.

Potzger and Van Engel (1942) give a sobering review of the manipulation attempted in the 1930's and later to try to increase the planktonic life and indirectly increase the fish productivity in this small, 27-acre lake. Between 1932 and 1935, 8,150 pounds of mineral fertilizers (1,250 pounds of super phosphate, 3,800 pounds of lime, 900 pounds of ammonium sulfate, 1,000 pounds of muriate of potash, and 1,200 pounds of cyanimid) were added while in 1936, 3,000 pounds of soybean meal were added and in 1939, 2,000 pounds of cottonseed oil were dumped in to induce plankton growth. Only limited sustained success was achieved, mainly with the organic fertilizers.

In 1942 and 1961 the lake was treated with rotenone to remove stunted fish, and after the final treatment, was restocked with brook and rainbow trout (Wisconsin Department of Natural Resources information).

Despite all of these additions of excessive amounts of mineral and organic fertilizers, fish poisons, and exotic fish, the macroscopic aquatic vegetation in 1974 appeared more diverse than by all previous accounts. Thus it becomes apparent that not all insults to the natural equilibrium of a plant community are necessarily detrimental, a fact which makes accuracy in predictive environmental impact very difficult.

Najas marina L.

The spread of the unmistakable spiny naiad (*Najas marina*) has been very well documented in the Great Lakes states of Minnesota (Rosendahl, 1939), Illinois (Winterringer, 1966; Swink, 1974), Michigan (Voss, 1972; Near & Belcher, 1974) and Ohio (Wentz & Stuckey, 1971). Its increased occurrence in Wisconsin in recent years is notable especially since many of the state's lakes have been consistently well collected over the years by such people as N. C. Fassett, N. Hotchkiss, and J. Meriläinen.

Ross and Calhoun (1951) reported the first collection made in Wisconsin in 1941 from Random Lake (Sheboygan County), and by 1968 (Meriläinen, 1968 [editorial comment by H. H. Iltis, p. 170]) the species was known also from Racine County (but incorrectly attributed to Kenosha County). Swink (1974) indicates the first Kenosha County collection in 1967 from Camp Lake (T1N, R20E, Sections 21, 28, 29; U. Rowlatt s.n., 29 July 1967, MOR) and it was subsequently collected by R. H. Read from the same locality in 1970 (Read 779, WIS). In Camp Lake, which is almost surrounded by residential development, spiny naiad occurs with the recently introduced *Ruppia maritima* L. var. *occidentalis* (S. Watson) Graebner (first Wisconsin collection: Dane County, Lake Mendota, in 1952; WIS).

Read also noted the persistent occurrence of *N. marina* in 1972 in Long Lake (T3N, R19E, Sections 16, 20, 21), Racine County, where it was first collected by C. T. Lind (Lind 88I, WIS) in 1965. Farther to the north, in Winnebago County, this species was collected from Rush Lake (T17N, R16E, Section 27; Dep. Natural Resources 4435A, 31 August 1971, OSH), a locality diverse in migratory waterfowl (which probably account for its rapid spread). With the addition of a new sight record in 1974 from Silver Lake (T1N, R20E, Sections 8, 9, 16, 17), Kenosha County by R. Read, it appears that *Najas marina* has become a well established and increasingly common species in many of southeastern Wisconsin's lakes.

Rhynchospora fusca (L.) Ait. f.

The range of *Rhynchospora fusca* in eastern North America is Newfoundland to Ontario and south to New England, New York, Delaware, and Michigan according to Fernald (1950). Gleason and Cronquist (1963) also include "around the Great Lakes" in their range description; however, Wisconsin and Minnesota are not specifically mentioned. Additionally, according to Deam (1940), Jones and Fuller (1955), and Braun (1967), *R. fusca* does not occur in Indiana, Illinois, or Ohio respectively. The range map of Hultén (1958, map 37) shows the amphi-Atlantic distribution of *R. fusca.*

In the upper midwest, Lakela (1965) mentions *R. fusca* as one of the less common herbaceous species occurring in sphagnaceous bogs, and maps two sites where it occurs in St. Louis County, northeastern Minnesota. Voss (1972) maps its occurrence in Michigan on Isle Royale and 14 counties bordering Lakes Superior, Michigan, and Huron in northern and northeastern parts of the state and two counties in southwestern Michigan.

Greene (1953) documents one Wisconsin location for *R. fusca* in the far northwestern portion of the state at Port Wing, Bayfield County. The collection was made by L. S. Cheney in 1897 and probably comes from the Lake Superior bog there.

Two new sites where *R. fusca* has been recently collected by us in Wisconsin (Tans 935, August 11, 1974; Tans 921, August 10, 1974) are northern bogs on the Apostle Islands off the Bayfield Peninsula, on Stockton Island (Ashland County: T51N, R2W, Section 1) and Madeline Island (Ashland County: T50N, R3W, Section 24). Both sites are similar in that they are extensive, undisturbed, open *Sphagnum* bogs adjacent to lagoons formed behind long, curving sand spits.

The Stockton Island bog is owned by the Wisconsin Department of Natural Resources and managed as a wilderness recreation area. Big Bay bog on Madeline Island, within Big Bay State Park, has been recommended as a State Scientific Area by Scientific Areas Preservation Council staff.

The vegetative composition of the two bogs, which lie about ten miles apart, is very similar, and is characterized by a quaking *Sphagnum* base, thoroughly interwoven with roots and rhizomes. Several genera of low or prostrate ericaceous shrubs occur including *Andromeda, Chamaedaphne, Kalmia, Ledum,* and *Vaccinium,* but the hallmark of these acid bogs is the dominance of Cyperaceae including nearly twenty species in six genera: *Carex, Cladium, Dulichium, Eriophorum, Rhynchospora,* and *Scirpus.* Carnivorous plants on the bog mat include the sundews, *Drosera rotundifolia* and *D. intermedia,* bladderworts, *Utricularia intermedia* and *U. cornuta,* and pitcher plant, *Sarracenia purpurea.* Additional plants worthy of mention are *Eriocaulon septangulare, Scirpus hudsonianus, S. subterminalis,* and *Xyris montana.*

Both *Rhynchospora alba* and *R. fusca* occur commonly on the open mats. *R. fusca* can be distinguished from *R. alba* in the field by its filiform leaves, rhizomatous habit, and brown scales, although those of *R. alba* may turn brownish in age.

Scirpus subterminalis Torr.

Scirpus subterminalis, an often submersed aquatic member of the Cyperaceae, has been reported as being restricted primarily to northern Wisconsin (Greene, 1953). Several southward extensions of the species have been discovered in recent years. In Adams County in central Wisconsin, a collection was made by W. Tans (1089, September 19, 1974) from Crooked Lake (T15N, R7E, Section 24) where large colonies were observed in a muck-marl bottom portion of the lake in about 16 cm of water. In Jefferson County several sight records have been made by different botanists (R. H. Read, J. H. Zimmerman) from Red Cedar Lake (T6N, R13E, Sections 17 and 20), a lake containing many interesting aquatic plants. A recent additional record in southeastern Wisconsin has been made in Walworth County (Swink, 1974), just to the south of Jefferson County.

From the number of collections in WIS it would appear that the species is somewhat rare in the state, but the plant is probably quite undercollected because of its aquatic nature as well as the fact that it is often sterile [such reasons are supported by Moyle (1941) who stated that it is common in northeastern Minnesota despite only one collection in MIN up to that time; also in Minnesota, Lakela (1965) states that *Scirpus subterminalis* is frequent in northern lakes but seldom in fruit].

SUMMARY

New distributional and ecological data for the following 16 vascular plants of restricted, misinterpreted, or expanding range in Wisconsin are given, with reference to their published status in other western Great Lakes states:

Anemone caroliniana Walt.
Aster furcatus Burgess
Astragalus crassicarpus Nutt.
Carduus nutans L.
Carex concinna R. Br.
Carex folliculata L.
Carex michauxiana Boeckl.
Chaerophyllum procumbens (L.) Crantz
Eleocharis rostellata Torr.
Eupatorium sessilifolium var. *brittonianum* Porter
Festuca occidentalis Hook.
Lespedeza leptostachya Engelm.
Littorella americana Fern.
Najas marina L.
Rhynchospora fusca (L.) Ait. f.
Scirpus subterminalis Torr.

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A FLORISTIC ANALYSIS OF THE VASCULAR PLANTS OF A MARSH AT PERRY'S VICTORY MONUMENT, LAKE ERIE[1]

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High waters and wind and wave action of Lake Erie during a severe northeast storm on 14 November 1972 broke the retaining wall along the southwest shore at the Perry's Victory and International Peace Memorial at Put-in-Bay, South Bass Island, Ottawa County, Ohio (Fig. 1). Portions of the lawn around Perry's Victory Monument were flooded. Sustained high water during the summers of 1973 and 1974 has maintained about a two-acre marsh on the southwest side of the Monument. The new marsh, called here "Perry's Victory Monument Marsh," provides an excellent example of a new plant community of aquatic and marsh species developing in an area whose plant community formerly consisted of so-called "lawn weeds," a lawn predominantly of grasses and associated species of roadsides. The new community is one typically associated with ponds and marshes on the Erie Islands and is maintained by the natural disturbance of the fluctuating water levels of Lake Erie, whereas the former lawn community is one associated with and maintained by man as an artificially disturbed plant community.

During the summer of 1974 an inventory was taken of all of the species of vascular plants in the flooded area. The plants were grouped into three basic ecological categories: A, The aquatic or marsh plants that moved into the area because of the high water; B, The lawn or roadside plants that were able to survive in or around the edge of the marsh as "remnants" from the former lawn; and C, The plants of both wet and dry habitats that have either moved into the new marsh or survived as remnants from the former lawn. The local origin of the plants in group C cannot be ascertained. Information was recorded on the abundance of the plants in the marsh, their abundance on the Erie Islands, their origin or geographical affinities, and, if non-indigenous, their status and time of introduction into the flora of the Erie Islands. This information is assembled in Table 1 and the statistical information derived from it is presented in Tables 2, 4, 5, and 6. An aerial view of the site on the southwest side of Perry's Victory Monument shows the area that was flooded and the new marsh that developed (Fig. 2). A vegetation map (Fig. 3) shows the position and extent of the major dominant vegetation zones that developed in a portion of the marsh and the predominant species in each zone.

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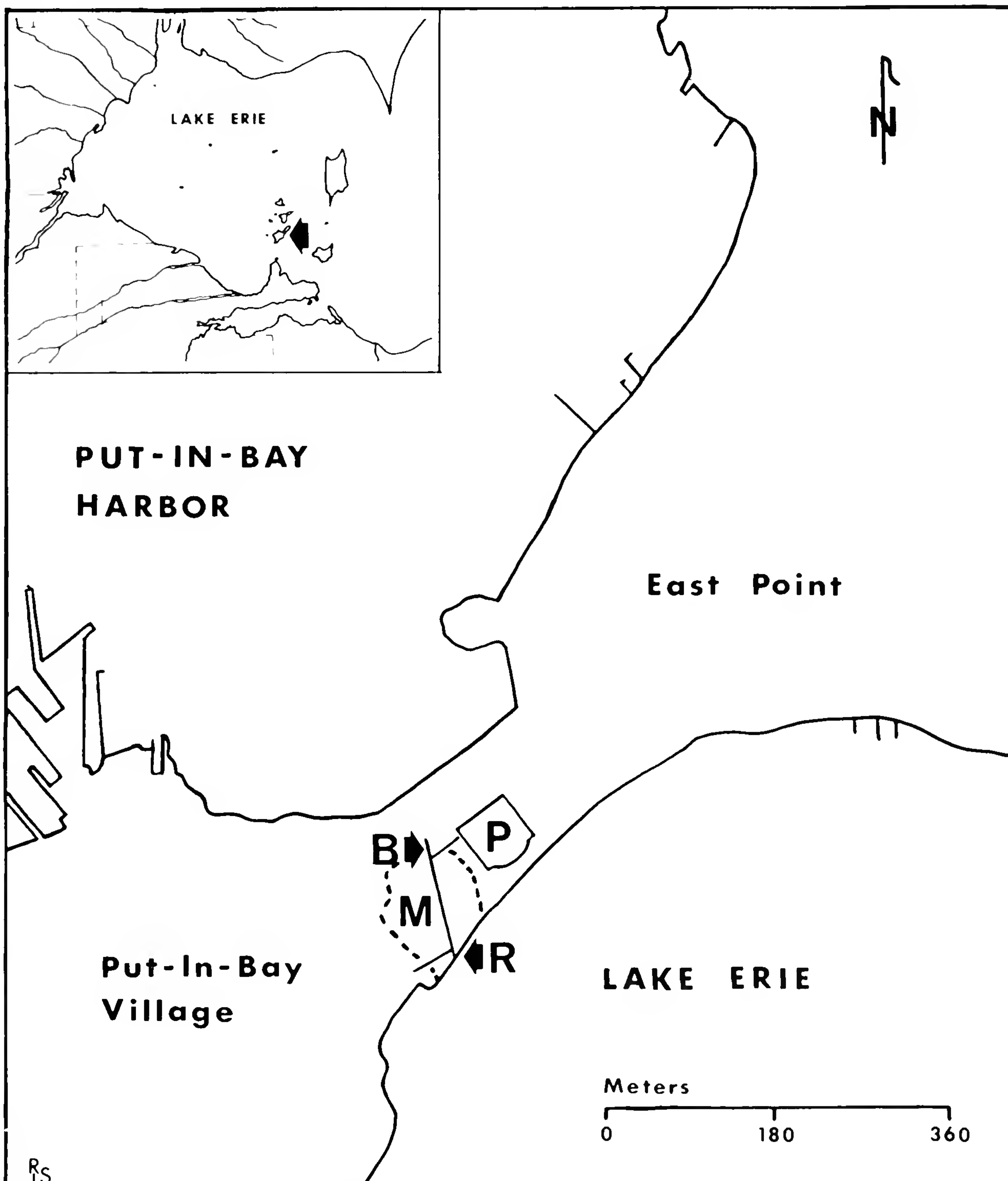

Fig. 1. Location of Perry's Victory Monument Marsh on South Bass Island, Ohio.

B = Boardwalk M = Perry's Victory Monument Marsh
R = Retaining Wall P = Perry's Victory Monument

HISTORY OF THE SITE

The site selected for Perry's Victory Monument was the low, marshy, wooded narrow isthmus between the village of Put-in-Bay and that portion of South Bass Island referred to as East Point (Fig. 1). Known as Chapman's Marsh or Chapman's Pond, the site was cleared in the summer of 1912 for the construction of the Monument (Frohman, 1971, pp. 96-97; Core, 1948, p. 26). No records of the original flora of Chapman's Pond are known, and no published floristic studies are known for the Monument site itself. In recent years the changes in the aquatic vascular plant flora of Put-in-Bay harbor have been studied (Stuckey, 1971), and one species, *Rorippa sylvestris,* was reported as new to the flora of the Erie Islands from the lawn at Perry's Victory Monument (Stuckey, 1968b).

TABLE 1. List of the Vascular Plants of Perry's Victory Monument Marsh with Information on their Status, Abundance in the Marsh and on the Erie Islands, and Geographical Origin or Affinity.

Species[a]	Status[b]	Abundance in Marsh[c]	Abundance on Erie Islands[d]	Origin or Affinity[e]
A. Aquatic or Marsh Plants that have moved into the area because of high water				
Alisma plantago-aquatica var. *parviflorum* Water-plantain	I	Occasional	Occasional-Common	Widespread
Alisma plantago-aquatica var. *americanum* Water-plantain	I	Rare	Occasional?	Western

[a]Nomenclature is based on an unpublished manuscript, *Flora of the Erie Islands: Its Origin, History, and Change,* by Ronald L. Stuckey and Thomas Duncan.

[b]I. Indigenous; NI. Non-indigenous.

[c]Abundant: in large numbers and dominant.
Common: in large numbers, but not appearing dominant.
Occasional: more or less scattered throughout the marsh.
Rare: few in number and at only one or two places in the marsh.

[d]Abundant: occurring in all or almost all suitable habitats and generally on more than 15 islands.
Common: frequent in suitable habitats and generally on 3-8 islands.
Occasional: infrequent or scattered in suitable habitats and generally on 3-8 islands.
Rare: in restricted habitats and on 1-3 islands or in a few locations on one island.
Local: occurring only in Perry's Monument Marsh on the Erie Islands.
Some plants are listed in intermediate categories, including: Common-Abundant, Occasional-Common, Rare-Occasional.

[e]Indigenous Species: Each species is categorized on the basis of its total geographical distribution in North America, with each group being considered a geographical element of the flora.

Widespread: occurring throughout most of North America, continental United States, or throughout eastern United States and eastern Canada east of the Mississippi River.

Eastern: occurring on the Atlantic Coastal Plain or in the Southern Appalachian Mountains and ranging inland north of the glacial boundary into the Great Lakes Region sometimes northwest to Minnesota, the Dakotas, and/or Manitoba.

Western: occurring in the Rocky Mountains or other parts of western North America and ranging north of the glacial boundary through the northern plains states, the Great Lakes Region, and sometimes as far east as New England.

Southern: occurring in southern United States, the Ozarks, or the unglaciated Mississippi River basin, sometimes eastward to the southern Atlantic Coast, and ranging north and northeast of the glacial boundary; with many reaching their northern limits in the southern Great Lakes Region, and in some cases on the shores of Lake Erie in Ohio, southern Michigan, and/or in southern Ontario.

Endemic: originating and confined to the islands in Lake Erie or possibly the shores of Lake Erie on the nearby mainland.

Non-Indigenous Species. Each species is listed according to the country or continent where it is native. The earliest record for each non-indigenous species is based on the first recorded observation or first preserved specimen record in a herbarium. These records generally reflect the approximate time when a species may have moved into the area or became established.

Before 1900 (based on report by Moseley, 1899).
Since 1900 (based on report by Core, 1948).
Specific year since 1900 (based on earliest known herbarium specimen record).

TABLE 1 (Continued)

Species[a]	Status[b]	Abundance in Marsh[c]	Abundance on Erie Islands[d]	Origin or Affinity[e]
Bidens cernuus Nodding Beggarticks	I	Abundant	Occasional-Common	Widespread
Bidens connatus Swamp Beggarticks	I	Common	Occasional-Common	Eastern
Boltonia asteroides Boltonia	I	Rare	Rare	Southern
Butomus umbellatus Flowering-rush	NI	Common	Common	Europe 1936
Carex granularis Sedge	I	Rare	Rare-Occasional	Widespread
Cyperus engelmannii Engelmann's Cyperus	I	Rare	Rare	Western
Cyperus erythrorhizos Red-rooted Cyperus	I	Rare	Rare-Occasional	Widespread
Cyperus ferruginescens Umbrella Sedge	I	Occasional	Occasional-Common	Widespread
Cyperus rivularis River Sedge	I	Rare	Occasional	Widespread
Cyperus strigosus Galingale	I	Occasional	Occasional	Widespread
Eleocharis erythropoda Spike-rush	I	Occasional	Occasional	Widespread
Eleocharis intermedia Spike-rush	I	Rare	Rare	Eastern
Eleocharis obtusa Spike-rush	I	Rare	Occasional	Widespread
Epilobium glandulosum Willow-herb	I	Rare	Rare-Occasional	Widespread
Epilobium hirsutum Great Hairy Willow-herb	NI	Rare	Occasional	Europe 1959
Eupatorium perfoliatum Boneset	I	Occasional	Occasional-Common	Widespread
Heteranthera dubia Water Star-grass	I	Occasional	Occasional	Widespread
Hibiscus moscheutos (*H. palustris*) Swamp Rose Mallow	I	Rare	Occasional	Eastern
Juncus dudleyi Dudley's Rush	I	Occasional	Occasional-Common	Widespread
Juncus torreyi Torrey's Rush	I	Common	Occasional	Western
Leersia oryzoides Rice Cut Grass	I	Occasional	Occasional-Common	Widespread
Lindernia dubia False Pimpernel	I	Occasional	Occasional	Widespread
Lycopus americanus Water Horehound	I	Occasional	Occasional-Common	Widespread

TABLE 1 (Continued)

Species[a]	Status[b]	Abundance in Marsh[c]	Abundance on Erie Islands[d]	Origin or Affinity[e]
Lycopus europaeus Water Horehound	NI	Rare	Occasional-Common	Europe 1963
Lycopus uniflorus Water Horehound	I	Occasional	Occasional	Western
Lythrum dacotanum Common Loosestrife	I	Rare	Occasional	Southern
Mentha arvensis Wild Mint	I	Rare	Occasional	Widespread
Myriophyllum exalbescens Water-milfoil	I	Occasional	Common	Widespread
Mimulus ringens Monkey Flower	I	Occasional	Occasional-Common	Widespread
Nymphaea tuberosa White Water-lily	I	Occasional	Occasional	Widespread
Penthorum sedoides Ditch Stonecrop	I	Occasional	Occasional-Common	Widespread
Phyla lanceolata (*Lippia lanceolata*) Fogfruit	I	Rare	Rare	Southern
Polygonum amphibium var. *emersum* Water Smartweed	I	Rare	Occasional-Common	Widespread
Polygonum lapathifolium Nodding Smartweed	I	Occasional	Occasional-Common	Widespread
Polygonum pensylvanicum var. *eglandulosum* Pennsylvania Smartweed	I	Rare	Occasional	Endemic
Polygonum punctatum Dotted Smartweed	I	Rare	Occasional	Widespread
Potamogeton crispus Curly Pondweed	NI	Occasional	Occasional-Common	Europe 1931
Potamogeton foliosus Leafy Pondweed	I	Rare	Occasional-Common	Widespread
Potamogeton illinoensis Illinois Pondweed	I	Rare	Rare	Western
Ranunculus pensylvanicus Pennsylvania Buttercup	I	Rare	Rare	Western
Ranunculus sceleratus Cursed Crowfoot	I	Rare	Occasional-Common	Widespread
Rorippa palustris var. *fernaldiana* Marsh Cress	I	Rare	Occasional	Widespread
Rorippa palustris var. *hispida* Marsh Cress	I	Occasional	Occasional	Western
Rorippa sylvestris Creeping Yellow Cress	NI	Abundant	Local	Europe 1967
Rumex maritimus var. *fueginus* Golden Dock	NI	Rare	Local	Eastern N. America 1974

TABLE 1 (Continued)

Species[a]	Status[b]	Abundance in Marsh[c]	Abundance on Erie Islands[d]	Origin or Affinity[e]
Rumex verticillatus Swamp Dock	I	Rare	Occasional-Common	Southern
Sagittaria cuneata Wedge-shaped Arrowhead	I	Rare	Rare	Western
Sagittaria latifolia Arrowhead	I	Common	Occasional-Common	Widespread
Salix rigida Stiff Willow	I	Rare	Occasional	Southern
Scirpus fluviatilis River Bulrush	I	Rare	Occasional-Common	Western
Scirpus validus Soft-stemmed Bulrush	I	Common	Occasional-Common	Widespread
Scutellaria lateriflora Mad Dog Skullcap	I	Occasional	Occasional-Common	Widespread
Senecio glabellus Butterweed	NI	Rare	Local	Southern U.S. 1974
Sium suave Water-parsnip	I	Rare	Rare	Widespread
Sparganium eurycarpum Bur-reed	I	Common	Occasional-Common	Widespread
Strophostyles helvola Trailing Wild Bean	I	Rare	Common	Southern
Typha angustifolia Narrow-leaved Cattail	I	Occasional	Common	Eastern
Verbena hastata Blue Vervain	I	Occasional	Occasional-Common	Widespread
B. Lawn or Roadside Plants that are able to survive in the marsh as "remnants" from former conditions				
Acer saccharinum Silver Maple	I	Occasional	Common	Widespread
Agropyron repens Quack Grass	NI	Common	Occasional-Common	Europe before 1900
Agrostis gigantea (*A. alba*) Red Top	NI	Abundant	Common	Europe before 1900
Agrostis stolonifera Creeping Bent	NI	Abundant	Local	Europe 1974
Amaranthus retroflexus Pigweed	NI	Occasional	Occasional-Common	Tropical America before 1900
Ambrosia artemisiifolia Common Ragweed	I	Occasional	Common	Western
Ambrosia trifida Giant Ragweed	I	Occasional	Occasional	Widespread

TABLE 1 (Continued)

Species[a]	Status[b]	Abundance in Marsh[c]	Abundance on Erie Islands[d]	Origin or Affinity[e]
Celtis occidentalis Hackberry	I	Rare	Abundant	Widespread
Cerastium vulgatum Mouse-eared Chickweed	NI	Rare	Occasional-Common	Eurasia before 1900
Chenopodium album Lamb's Quarters	NI	Occasional	Occasional-Common	Europe before 1900
Cirsium arvense Canada Thistle	NI	Occasional	Common	Europe before 1900
Commelina communis Dayflower	NI	Rare	Occasional	Asia 1940
Conyza canadensis Horseweed	I	Rare	Occasional-Common	Widespread
Dactylis glomerata Orchard Grass	NI	Common	Common-Abundant	Europe before 1900
Daucus carota Wild Carrot	NI	Occasional	Common	Europe since 1900
Digitaria sanguinalis Crab Grass	NI	Occasional	Common	Europe before 1900
Eragrostis poaeoides Love Grass	NI	Rare	Local	Europe 1974
Erigeron annuus Daisy Fleabane	I	Occasional	Occasional-Common	Widespread
Erigeron philadelphicus Philadelphia Fleabane	I	Occasional	Common	Widespread
Euphorbia supina Milk Purslane	I	Rare	Common	Widespread
Festuca pratensis (*F. elatior*) Meadow Fescue	NI	Common	Occasional-Common	Europe before 1900
Galinsoga ciliata Galinsoga	NI	Occasional	Rare	Tropical America since 1900
Holcus lanatus Valvet Grass	NI	Rare	Local	Europe 1974
Hordeum jubatum Squirrel-tail Barley	I	Rare	Occasional-Common	Widespread
Lepidium virginicum Pepper-grass	I	Rare	Occasional-Common	Widespread
Lolium perenne Common Darnel	NI	Common	Rare	Europe before 1900
Matricaria chamomilla Wild Chamomile	NI	Rare	Occasional	Europe 1902
Medicago lupulina Black Medic	NI	Occasional	Common	Europe before 1900
Melilotus alba Sweet Clover	NI	Occasional	Common	Europe before 1900

TABLE 1 (Continued)

Species [a]	Status [b]	Abundance in Marsh [c]	Abundance on Erie Islands [d]	Origin or Affinity [e]
Oxalis europaea Sour-grass	I	Occasional	Common	Widespread
Phleum pratense Timothy	NI	Common	Common-Abundant	Europe before 1900
Plantago lanceolata Narrow-leaved Plantain	NI	Occasional	Occasional-Common	Europe before 1900
Plantago rugelii Broad-leaved Plantain	I	Occasional	Common	Widespread
Poa annua Blue Grass	NI	Rare	Rare	Eurasia before 1900
Poa compressa Blue Grass	NI	Common	Occasional-Common	Eurasia before 1900
Poa pratensis Blue Grass	I	Common	Occasional-Common	Widespread
Polygonum aviculare Knotweed	NI	Occasional	Occasional-Common	Europe before 1900
Populus deltoides Cottonwood	I	Rare	Occasional-Common	Widespread
Portulaca oleracea Purslane	NI	Rare	Common	Europe before 1900
Potentilla norvegica Rough Cinquefoil	I	Rare	Occasional	Widespread
Prunella vulgaris Heal-all	I	Rare	Occasional-Common	Widespread
Rhus radicans Poison Ivy	I	Occasional	Abundant	Widespread
Rubus sp. Blackberry	I	Rare	Occasional-Common	Widespread
Solidago altissima Goldenrod	I	Rare	Occasional-Common	Widespread
Sonchus uliginosus Sow Thistle	NI	Rare	Occasional-Common	Europe since 1900
Stellaria graminea Grass Chickweed	NI	Abundant	Local	Europe 1967
Stellaria media Common Chickweed	NI	Occasional	Occasional-Common	Eurasia before 1900
Taraxacum officinale Dandelion	NI	Occasional	Abundant	Europe before 1900
Teucrium canadense Germander	I	Occasional	Occasional-Common	Widespread
Trifolium hybridum Alsike Clover	NI	Occasional	Occasional	Europe before 1900
Trifolium repens White Clover	NI	Occasional	Common	Europe before 1900

TABLE 1 (Continued)

Species[a]	Status[b]	Abundance in Marsh[c]	Abundance on Erie Islands[d]	Origin or Affinity[e]
C. Plants of Both Wet and Dry Habitats that have either moved into the marsh area or survived as remnants from former conditions				
Acalypha rhomboidea Three-seeded Mercury	I	Rare	Common	Widespread
Bidens frondosus Beggarticks	I	Common	Occasional-Common	Widespread
Convolvulus sepium Hedge Bindweed	I	Occasional	Common	Widespread
Cyperus esculentus Yellow Nut-grass	I	Occasional	Rare	Widespread
Echinochloa crus-galli Barnyard Grass	NI	Occasional	Occasional-Common	Europe before 1900
Echinochloa muricata (*E. pungens*) Barnyard Grass	I	Occasional	Occasional-Common	Widespread
Impatiens capensis Jewelweed	I	Occasional	Common	Widespread
Lysimachia nummularia Moneywort	NI	Rare	Rare	Europe before 1900
Panicum capillare Old-witch Grass	I	Occasional	Occasional-Common	Widespread
Polygonum persicaria Lady's Thumb	NI	Occasional	Occasional-Common	Europe before 1900
Rumex crispus Curly Dock	NI	Common	Occasional-Common	Europe before 1900
Salix fragilis Crack Willow	NI	Rare	Occasional-Common	Europe since 1900
Solanum dulcamara Bittersweet Nightshade	NI	Rare	Abundant	Europe before 1900
Solanum nigrum Black Nightshade	NI	Occasional	Occasional	Europe before 1900
Solidago graminifolia Grass-leaved Goldenrod	I	Occasional	Common	Western
Veronica peregrina Purslane Speedwell	I	Occasional	Occasional	Widespread
Xanthium strumarium Cocklebur	NI	Rare	Occasional	Europe before 1900

FLORISTIC ANALYSIS

Status of the Species. The species in any flora may be placed into two groups, the indigenous (native species) and the non-indigenous (non-native or foreign species). As shown in Tables 1 and 2, the majority of the aquatic and marsh species (category A) belong to the indigenous group (53 of 60 or 88%), whereas the "remnant" lawn and roadside species (category B) belong to the non-indigenous group (31 of 51 or 62%). The numbers of species that live in both wet and dry habitats (category C) are about equal for the indigenous and non-indigenous groups (9 and 8 species, respectively). As a whole, Perry's Monument Marsh is composed of somewhat over half indigenous species (82 of 128 or 64%). The flora of the marsh is also about equally comprised of the aquatic and marsh species (60 species) and the "remnant" lawn and roadside species (51 species).

Abundance of the Species. As presented in Tables 1 and 2, most of the species recorded (108 of 128 or 84%) are occasional or rare in the marsh. Half of these are considered occasional (54 species) and half are considered rare (54 species). Very few are therefore, common or abundant. Of the aquatic and marsh species, half are rare (31 of 60 or 50%). The "remnant" lawn and roadside species are about equally divided between occasional and rare (23 and 18, respectively).

Abundance of the Species in the Marsh Compared to Their Abundance on the Erie Islands and in the State of Ohio. Compared to the flora of the Erie Islands as a whole, most of the species in the marsh (105 of 128 or 82%) are designated as either abundant, common, occasional, or a combination of two of these designations (Tables 1 and 2). Twenty-three species of the marsh are rare or rare-occasional in the flora of the Erie Islands, including seven known to occur

Fig. 2. Aerial view of Perry's Victory Monument Marsh from atop the Monument. Upper portion of photograph corresponds to the vegetation map in figure 3. Photograph by Marvin L. Roberts, 12 August 1974.

only in Perry's Victory Monument Marsh. They are all non-indigenous species and are listed separately (Table 3, part A). Twelve of the rare species are known from only one or two other locations on the Erie Islands. Most of these are indigenous to the flora of the Erie Islands, and they are also listed separately (Table 3, part B). Most of the species in the marsh are also common or abundant and generally distributed in suitable habitats throughout the entire state of Ohio. Twelve species[2] of the marsh have a very limited distribution in Ohio:

1. *Alisma plantago-aquatica* var. *americanum* (*A. triviale*). Known only from Paulding and Wood counties in Ohio (Braun, 1967); expected in the marshes along western Lake Erie in Ohio, but its occurrence, abundance, and distribution there have not been studied.
2. *Butomus umbellatus*. In the marshes and roadside ditches in counties bordering along Lake Erie (Stuckey, 1968a); also Franklin County (Roberts, 1972).
3. *Cyperus engelmannii*. In the marshes and along the shore of Lake Erie in Ashtabula, Erie, Lucas, and Ottawa counties; known elsewhere in Ohio from only Auglaize, Licking, Logan, Stark, and Wayne counties (Braun, 1967).
4. *Eleocharis intermedia*. In the marshes and along the shore of Lake Erie in Erie, Lucas, and Ottawa counties; known elsewhere in Ohio from only Fairfield and Franklin counties (Braun, 1967).
5. *Epilobium hirsutum*. In the marshes in counties bordering Lake Erie and in counties in northeastern Ohio (Stuckey, 1970).
6. *Hibiscus moscheutos* (*H. palustris*). In the marshes in counties bordering Lake Erie and in a few places inland in eastern Ohio to as far south as Buckeye Lake, Licking County.
7. *Lycopus europaeus*. Only along the shore of Lake Erie in Erie, Lucas, and Ottawa counties (Stuckey & Phillips, 1970).
8. *Polygonum pensylvanicum* var. *eglandulosum*. Known on the islands from South Bass, Middle Bass, North Bass, Kelleys, and Middle (Myers, 1942; Core, 1948); known also from a specimen obtained in 1968 at East Harbor State Park (*Stuckey 7480*, OS) and one obtained in 1974 at the mouth of Old Woman Creek (*Stuckey 9550*, OS).
9. *Ranunculus pensylvanicus*. In certain counties north of the glacial border (Schaffner, 1932).
10. *Rumex maritimus* var. *fueginus*. In the marshes in counties bordering along Lake Erie and in counties in northeastern Ohio.
11. *Sagittaria cuneata*. In the marshes and along the shore of Lake Erie in Erie, Lucas, and Ottawa counties; known elsewhere in Ohio from only Auglaize and Pickaway counties (Braun, 1967).
12. *Senecio glabellus*. Known only from Preble County in southwestern Ohio (Schaffner, 1932).

Geographical Relationships of the Indigenous Species. Geographically most of the indigenous species in the marsh are widespread in their total distribution in North America (60 of 82 or 73%), whereas indigenous species of restricted distribution, the eastern, western, and southern species, are fewer (22 of 82 or 27%) as shown in Tables 1 and 2. These figures are similar for the total flora of the Erie Islands, 69% and 31%, respectively (Table 4). In general, the widespread species tend to be more prevalant (abundant, common, occasional) in the marsh

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[2]In addition to the references cited with these twelve species, additional records documenting their distribution in Ohio are based on specimens in The Ohio State University Herbarium.

TABLE 2. Summary Statistics Derived from Table 1 for the Floristic Analysis of the Vascular Plants of Perry's Victory Monument Marsh.

	Status			Abundance in the Marsh				Abundance on the Erie Islands								Origin or Affinity*							
																Indigenous Species					Non-Indigenous Species		
	Total Number of Species	Number of Indigenous Species	Number of Non-Indigenous Species	Abundant	Common	Occasional	Rare	Abundant	Common-Abundant	Common	Occasional-Common	Occasional	Rare-Occasional	Rare	Local	Widespread	Eastern	Western	Southern	Endemic	Europe	Other	Total
Category A	60	53	7	2	6	21	31	0	0	4	23	19	3	8	3	33	4	9	6	1	5	2	7
Category B	51	20	31	3	7	23	18	3	2	14	20	5	0	3	4	19	0	1	0	0	24	7	31
Category C	17	9	8	0	2	10	5	1	0	4	7	3	0	1	0	8	0	1	0	0	8	0	8
Totals	128	82	46	5	15	54	54	4	2	22	50	27	3	13	7	60	4	11	6	1	37	9	46
		128		128				105 of 128 = 82%				23 of 128 = 18%				60 of 82 = 73%			22 of 82 = 27%		46		
								128															

*This section is further analyzed in Table 4.

TABLE 3. Rare Vascular Plants of the Erie Islands in Perry's Victory Monument Marsh

A. Species known only from Perry's Victory Monument Marsh. These species are all non-indigenous to the flora of the Erie Islands.

Agrostis stolonifera
Eragrostis poaeoides
Holcus lanatus
Rumex maritimus var. *fueginus*
Rorippa sylvestris
Senecio glabellus
Stellaria graminea

B. Species known from one or two other locations in the Erie Islands. Species marked with an asterisk are non-indigenous to the flora of the Erie Islands.

Boltonia asteroides
Carex granularis
Cyperus engelmannii
Eleocharis intermedia
**Lysimachia nummularia*
Phyla lanceolata
**Poa annua*
Polygonum pensylvanicum var. *eglandulosum* (known from more than two locations)
Potamogeton illinoensis
Sagittaria cuneata
Sium suave
Ranunculus pensylvanicus

(37 of 60 or 62%) as shown in part A of Table 5. Species of restricted distribution are generally rare in the marsh (15 of 22 or 70%) as shown in part B of Table 5. Similar percentages probably also hold for the flora of the islands as a whole. Of the species of restricted range, the most significant figure is that half

TABLE 4. Summary Geographical Analysis of the Vascular Plant Flora of the Erie Islands.*

Floristic Element	Number of Species	Percent of Indigenous Flora	Percent of Total Flora
Widespread	392	69	47
Eastern	29	5	4
Western	78	14	9
Southern	58	10	7
Endemic	4	1	0.5
Hybrids	6	1	0.5
Total Number of Indigenous Species	567	100	68
Total Number of Non-Indigenous Species	270	–	32
Total Species	837	–	100

*Extracted from the unpublished *Flora of the Erie Islands: Its Origin, History, and Change,* by Ronald L. Stuckey and Thomas Duncan.

TABLE 5. Comparison of Geographical Relationships and Abundance of the Indigenous Species in Perry's Victory Monument Marsh

Geographical Relationship	Abundance in Perry's Victory Monument Marsh			
	Abundant	Common	Occasional	Rare
Part A.				
Widespread				
A. 33	1	3	17	12
B. 19	0	1	8	10
C. 8	0	1	6	1
Summary of Part A				
Total 60 species		37 of 60 = 62%		23 of 60 = 38%
Part B.				
Eastern				
A. 4	0	1	1	2
B. 0	0	0	0	0
C. 0	0	0	0	0
Western				
A. 9	0	1	2	6
B. 1	0	0	1	0
C. 1	0	0	1	0
Southern				
A. 6	0	0	0	6
B. 0	0	0	0	0
C. 0	0	0	0	0
Endemic				
A. 1	0	0	0	1
Summary of Part B				
Total 22 species		7 of 22 = 30%		15 of 22 = 70%

TABLE 6. Comparison of the Non-Indigenous Species of Perry's Victory Monument Marsh with their General Abundance on the Erie Islands

Number of Species in each Category		Abundance on the Erie Islands: Abundant; Common-Abundant	Common; Occasional-Common	Occasional	Rare	Local
A.	7	0	2	2	0	3
B.	31	2	15	8	3	3
C.	8	1	4	2	1	0
Totals	46	3	21	12	4	6

of them are western species (11 of 22 or 50%) as shown in Table 5, revealing a distinctive western element in the flora of the marsh. This western floristic element may give a clue as to the origin or direction of migration that some of the aquatic and marsh species have taken during their invasion into the western Lake Erie region since the retreat of the last glacier. One endemic, *Polygonum pensylvanicum* var. *eglandulosum,* was originally described from the Erie Islands by Myers (1942) and is also a rare shoreline plant of wet, open, naturally disturbed habitats created by fluctuating water levels. This plant occurs only along the calcareous shores of the Erie Islands, and on the mainland at East Harbor State Park and at the mouth of Old Woman Creek. Because of its limited total distribution and specific habitat on the islands, *P. pensylvanicum* var. *eglandulosum* is the only plant in the marsh that can be considered endangered throughout its entire range.

Geographical Relationships and Status of the Non-Indigenous Species. As is presented in Table 2, most of the non-indigenous species are European in origin (37 of 46 or 80%), and most of the non-indigenous species are also primarily of the "remnant" lawn and roadside flora (31 of 46 or 67%). Of these 31 species, 24 are European in origin. The origin of the non-indigenous aquatic and marsh flora is also mostly European (5 of 7 species). Most of the non-indigenous species arrived in the flora of the Erie Islands before 1900 and are now well established in man-disturbed habitats on the Islands. Such species are usually referred to as "weeds" and most of them are either common or abundant with a general distribution on the Islands (24 of 46 or 52%) as shown in Table 6.

MAJOR VEGETATION ZONES

A map of the predominant vegetation zones of a portion of Perry's Victory Monument Marsh gives an indication of the extent of the different kinds of plant communities (Fig. 3). These vegetation zones are grouped into three categories: I, the ones in the drier habitats; II, the ones where the water continued to fluctuate during the season forming diverse habitats; and III, the ones in open water or mudflat habitats. Each zone is briefly described as follows:

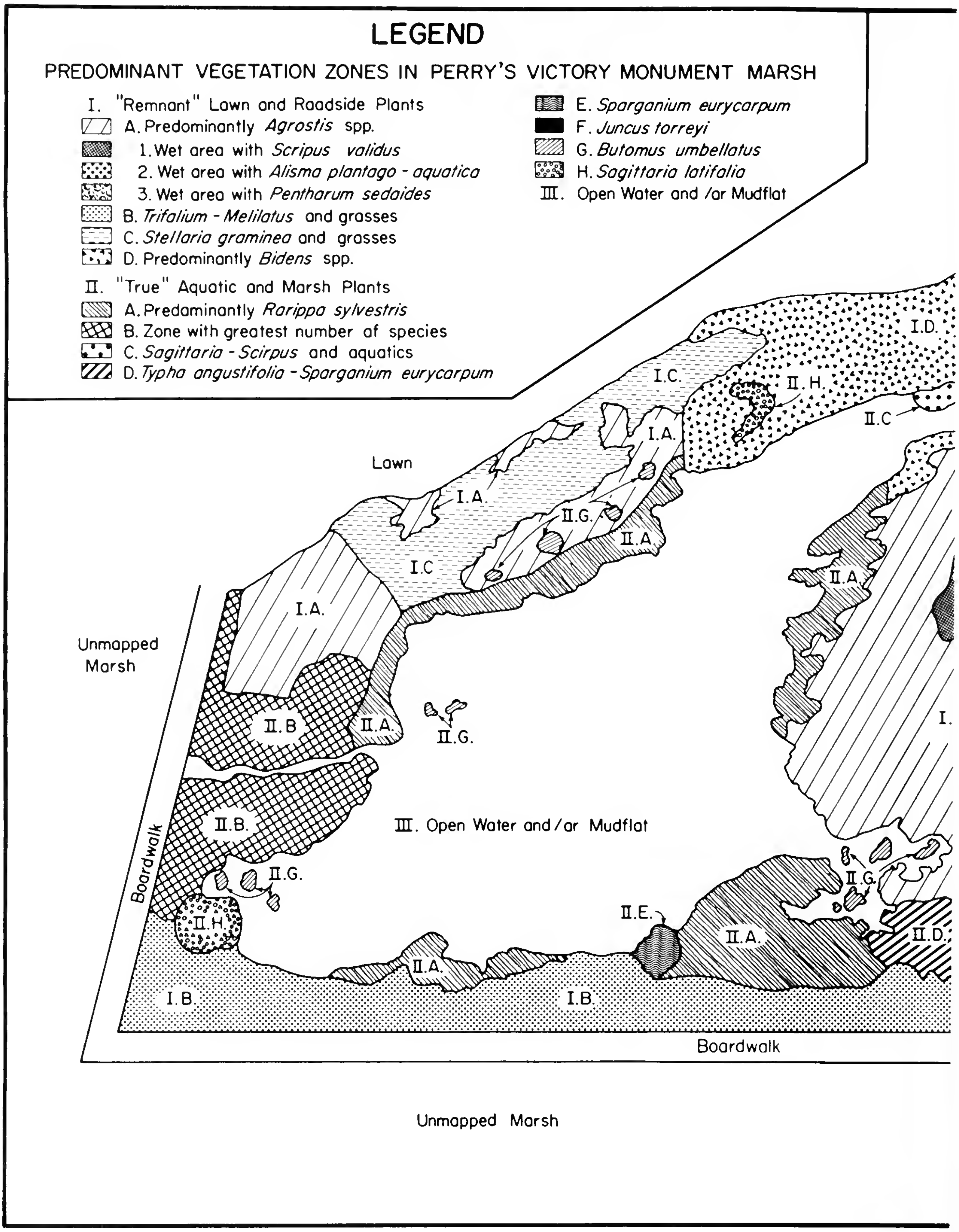
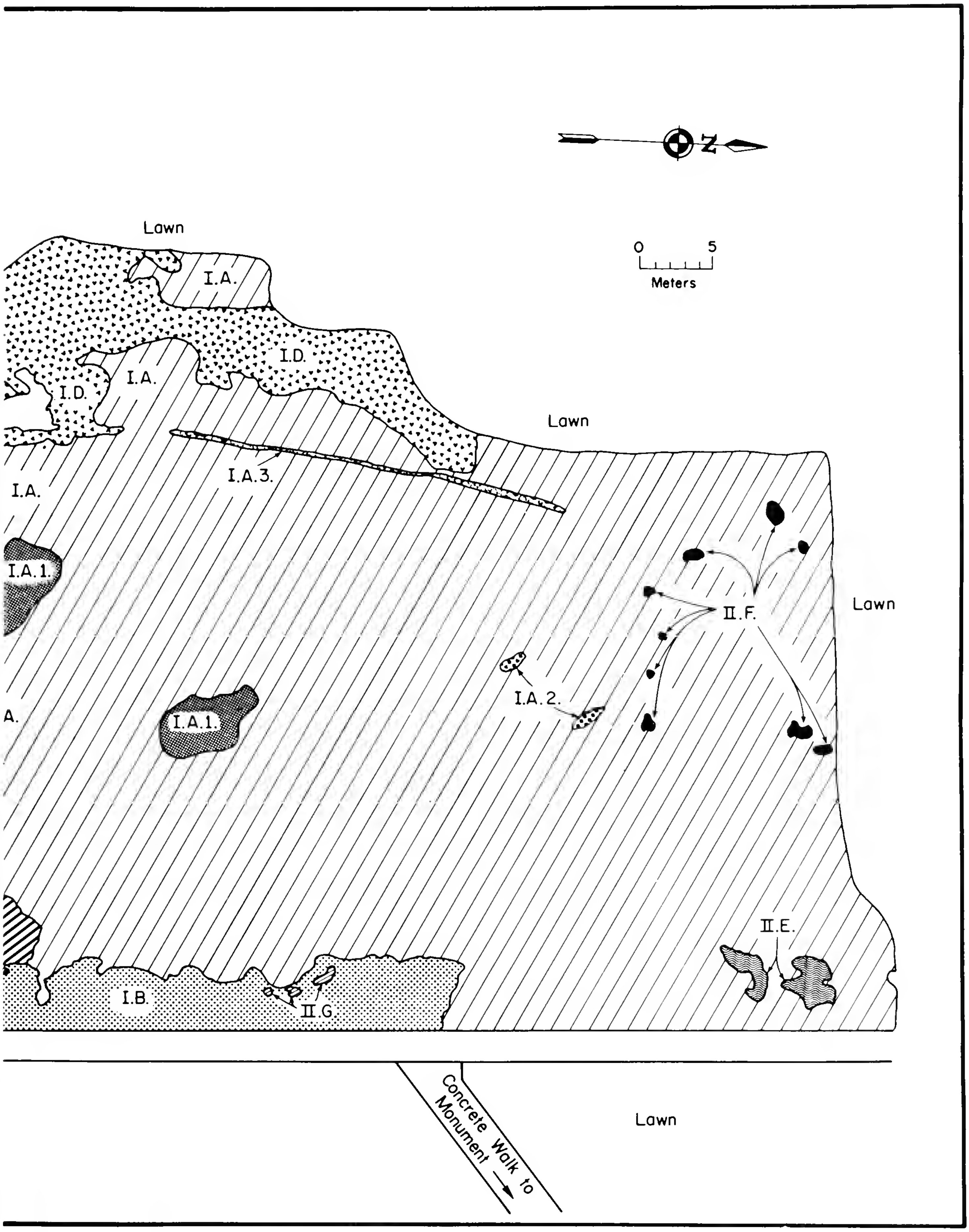


Fig. 3. Vegetation map of Perry's Victory Monument Marsh showing portion of the marsh between the boardwalk and lawn at the southwest portion of the property of the Perry's Victory and International Peace Memorial. August 1974. Original map prepared by Marjorie



Adams, Jeffrey Cunningham, and Lawrence Smith from ground surveys and aerial photographs taken from atop the Monument. Final map drafted by The Ohio State University Research Foundation.

I. Vegetation Zones Dominated Primarily by "Remnant" Lawn and Roadside Species of the Drier Areas Where the Water Levels Fluctuated the Least.

A. The largest zone composed predominantly of *Agrostis gigantea* and *Agrostis stolonifera.* Scattered throughout this zone are species of both the lawn habitat in the drier places and the marsh habitat in the wetter places. Some of the frequently occurring species are

Agrostis gigantea
Agrostis stolonifera
Alisma plantago-aquatica var. *americanum*
Alisma plantago-aquatica var. *parviflorum*
Bidens cernuus
Bidens frondosus
Butomus umbellatus
Cirsium arvense
Convolvulus sepium
Cyperus engelmannii
Cyperus erythrorhizos
Cyperus ferruginescens
Cyperus strigosus
Eleocharis erythropoda
Epilobium glandulosum
Festuca pratensis
Holcus lanatus
Juncus torreyi
Lindernia dubia
Lythrum dacotanum
Oenothera biennis
Penthorum sedoides
Polygonum persicaria
Rorippa sylvestris
Rumex crispus
Salix fragilis
Scirpus validus
Solidago graminifolia
Stellaria graminea
Teucrium canadense
Typha angustifolia
Veronica peregrina

Three small wet areas occur within zone A that are characterized by certain dominant plants as follows:

1. *Scirpus validus, Alisma plantago-aquatica, Bidens cernuus,* and *Lindernia dubia.*
2. *Butomus umbellatus* and *Alisma plantago-aquatica.*
3. *Scirpus validus, Bidens cernuus,* and *Penthorum sedoides.*

B. A zone along the northeast edge of the boardwalk composed predominantly of *Agrostis gigantea, Agrostis stolonifera, Trifolium repens, Melilotus alba, Festuca pratensis,* and *Plantago rugelii.* Some additional species scattered throughout this zone are

Acalypha rhomboidea
Acer saccharinum
Amaranthus retroflexus
Ambrosia artemisiifolia
Ambrosia trifida
Bidens frondosus
Butomus umbellatus
Chenopodium album
Cirsium arvense
Conyza canadensis
Cyperus esculentus
Daucus carota
Erigeron philadelphicus
Oenothera biennis
Oxalis europaea
Polygonum persicaria
Populus deltoides
Portulaca oleracea
Rumex crispus
Rubus sp.
Solanum nigrum
Stellaria graminea
Taraxacum officinale

C. A zone along the southwest edge adjacent to the mowed lawn. This zone is composed primarily of *Agrostis stolonifera, Bidens frondosus, Stellaria graminea,* and many of the remnant lawn species.

D. A large zone almost entirely of *Bidens cernuus, Bidens connatus,* and *Bidens frondosus.* This zone is certainly a transitional one between the lawn and the marsh.

TABLE 7. Species in Perry's Victory Monument Marsh Adjacent to the Boardwalk along the Southeast Edge (Zone II, B, Figure 3)

A. Dominant; mostly common aquatic and marsh species

Agrostis gigantea	*Rorippa sylvestris*
Bidens cernuus	*Rumex crispus*
Butomus umbellatus	*Sagittaria latifolia*
Echinochloa crus-galli	*Sparganium eurycarpum*
Juncus torreyi	

B. Subdominant; mostly aquatic and marsh species

Alisma plantago-aquatica var. *americanum*	*Mentha arvensis*
Alisma plantago-aquatica var. *parviflorum*	*Mimulus ringens*
Bidens connatus	*Nymphaea tuberosa*
Bidens frondosus	*Penthorum sedoides*
Boltonia asteroides	*Polygonum lapathifolium*
Carex granularis	*Polygonum pensylvanicum* var. *eglandulosum*
Cyperus erythrorhizos	*Polygonum persicaria*
Cyperus esculentus	*Polygonum punctatum*
Cyperus ferruginescens	*Ranunculus pensylvanicus*
Cyperus strigosus	*Ranunculus sceleratus*
Echinochloa muricata	*Rorippa palustris* var. *fernaldiana*
Eleocharis erythropoda	*Rorippa palustris* var. *hispida*
Eleocharis obtusa	*Rumex maritimus* var. *fueginus*
Epilobium glandulosum	*Scirpus fluviatilis*
Eupatorium perfoliatum	*Scirpus validus*
Impatiens capensis	*Scutellaria lateriflora*
Juncus dudleyi	*Senecio glabellus*
Leersia oryzoides	*Sium suave*
Lindernia dubia	*Solidago graminifolia*
Lycopus americanus	*Typha angustifolia*
Lycopus europaeus	*Verbena hastata*

C. Subdominant; mostly "remnant" lawn and roadside species

Acalypha rhomboidea	*Daucus carota*	*Plantago rugelii*
Agrostis stolonifera	*Eragrostis poaeoides*	*Poa annua*
Agropyron repens	*Erigeron philadelphicus*	*Sonchus uliginosus*
Amaranthus retroflexus	*Festuca pratensis*	*Stellaria graminea*
Ambrosia artemisiifolia	*Galinsoga ciliata*	*Stellaria media*
Ambrosia trifida	*Medicago lupulina*	*Taraxacum officinale*
Cirsium arvense	*Melilotus alba*	*Trifolium repens*
Chenopodium album	*Panicum capillare*	*Veronica peregrina*
Conyza canadensis		

II. Vegetation Zones Dominated Primarily by Aquatic and Marsh Species of the Wetter Areas Where the Water Levels Fluctuated the Most (Figs. 4, 5, 6).

A. The largest zone that existed between the open water and those zones dominated with grasses or species of *Bidens.* This zone is composed predominantly of *Rorippa sylvestris* and scattered clumps or individuals of *Butomus umbellatus, Scirpus validus, Bidens cernuus, Bidens frondosus,* and *Typha angustifolia.*

B. A large wide zone along the southwest edge of the boardwalk composed of the greatest number of species in any one zone in the marsh, with

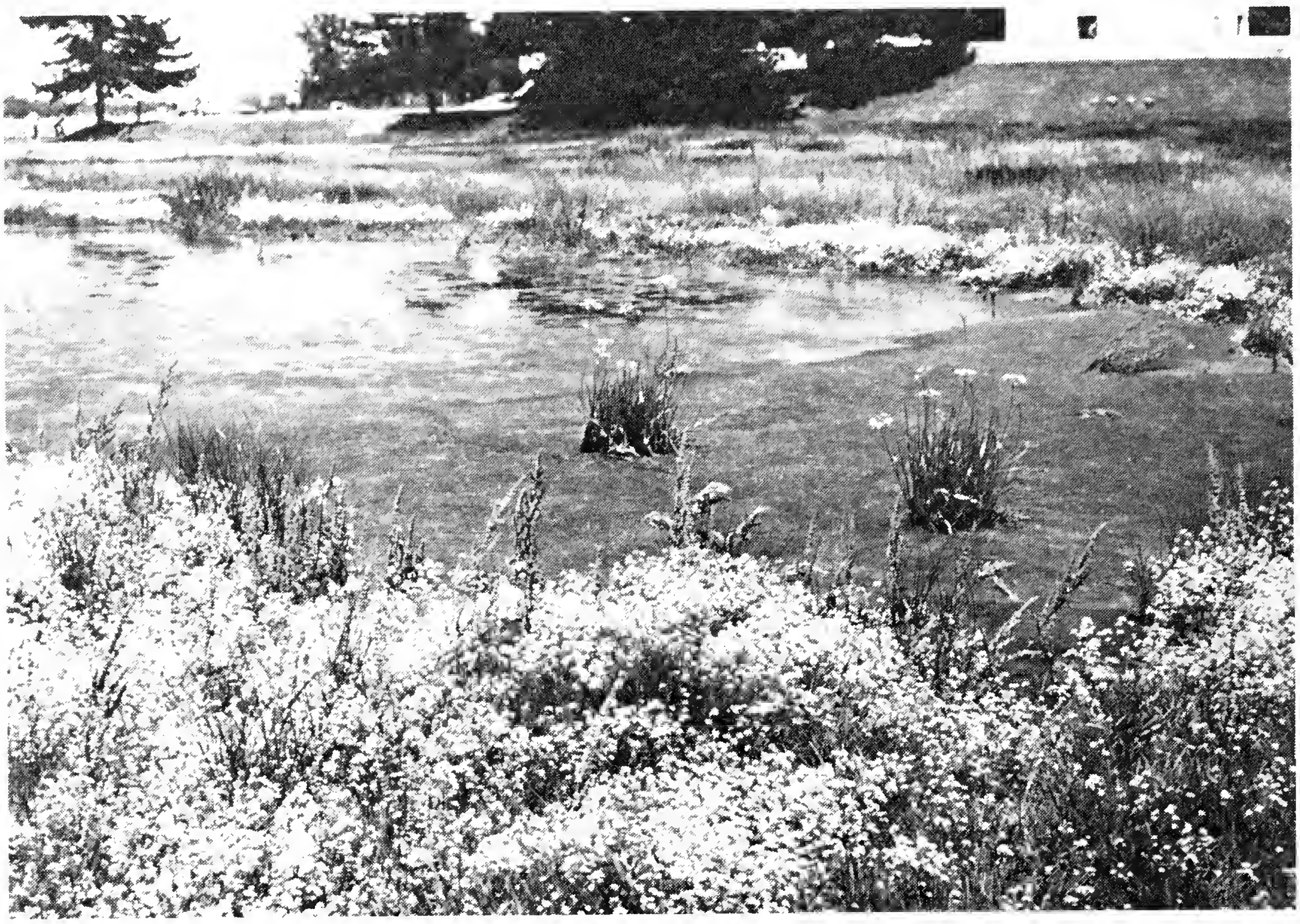


Fig. 4. Looking northeast, *Rorippa sylvestris* dominant with tall plants of *Rumex crispus* in foreground (Zone IIB), two clumps of *Butomus umbellatus* in center on mudflat (Zones IIG, III), *Rorippa sylvestris* and grasses in background (Zones IIA, IB), with base of Monument in far background. Photograph by Jane L. Forsyth, 24 June 1974.

no one species being dominant. Species of both the "remnant" lawn flora and the aquatic and marsh flora were here. Most of the species noted are listed in Table 7. Many of the rare species of the marsh occurred in this zone.

C. A zone primarily of *Sagittaria latifolia, Scirpus validus, Juncus torreyi, Rorippa sylvestris,* and *Eupatorium perfoliatum.*

D. A zone of *Typha angustifolia* and *Sparganium eurycarpum.*

E. A zone of *Sparganium eurycarpum.*

F. A zone of *Juncus torreyi.*

G. A zone of *Butomus umbellatus.*

H. A zone of *Sagittaria latifolia.*

III. Vegetation Zones of Open Water in June and July Which Became a Mudflat in August and September.

Most of the species inhabiting this zone are listed in Table 8.

The greatest diversity of vegetation zones and greatest diversity of species within zones occur in that portion of the marsh where the water level fluctuated the most throughout the season. This diversity can be maintained only under these changing conditions. If we consider the present abundance and vegetative reproductive behavior of the plants in the marsh in 1974, and the general

Fig. 5. Looking east to northeast, *Agrostis stolonifera* (Zone IIB) in right foreground, *Sagittaria latifolia* (Zone IIH) in right center, *Butomus umbellatus* (Zone IIG) on mudflat (Zone II) in left center, *Agrostis* spp. and *Rumex crispus* (Zone IB) predominate in background, with base of Perry's Monument in far background. Photograph by Thomas Duncan, 16 August 1974.

successional patterns of aquatic and marsh plants in the ponds on the Lake Erie Islands and in the marshes of western Lake Erie, Perry's Victory Monument Marsh will return to the lawn vegetation if the water is drained or remains at lower lake levels as it did before 1972. With some fluctuating water levels forming a shallow pond or broad mudflats, the marsh could form large zones of *Rorippa sylvestris* or become entirely dominated by *Typha angustifolia.* Although *Typha angustifolia* does not now form any extensive zone in the marsh, scattered individuals throughout the mudflat area are reproducing by rhizomes and could expand considerably within a year or two. *Typha angustifolia* is a very aggressive species in the western Lake Erie marshes and in many places covers broad areas almost to the exclusion of any other species. If water levels fluctuate at about the same depths as they did in 1974, or are allowed to fluctuate by artificial controls, a diversity of zones and species such as was seen in 1974 can be expected to reoccur and be maintained. If water levels were raised and stabilized artificially, a permanent pond would form and more submersed aquatic species, such as *Ceratophyllum demersum, Utricularia vulgaris, Elodea canadensis,* and *Potamogeton pectinatus,* would be expected to invade and become established. Consequently, species diversity as a whole for

Fig. 6. Looking north, *Sagittaria latifolia* and other plants on both sides of outlet (Zone IIB) in foreground, water and mudflat (Zone III) in center, and *Agrostis* spp. and other plants (Zone IA) in background with Put-in-Bay harbor and Gibraltar Island in far background. Photograph by Thoms Duncan, 16 August 1974.

the marsh would be expected to decrease and vegetation zones would become more uniform. The zones of marsh plants now present would move to nearby higher slopes, become narrower, and/or be eliminated depending on water level conditions, the adjacent topography, and local climatic and weather conditions. The probable dominant vegetation zones that could be expected under these three basic conditions are presented in Table 9.

SUMMARY

Because species of essentially two components of the flora of the Erie Islands are living together in this small area (about two acres), Perry's Victory Monument Marsh is an unusual plant community on the Erie Islands. A total of 128 species are recorded from the marsh compared to 837 known species that grow without cultivation for the entire flora of the Erie Islands. The flora of Perry's Victory Monument Marsh, therefore, represents 15% of the total known vascular plant flora of the Erie Islands. This percentage is believed to be quite high compared to any other locality of similar size on the Erie Islands. The greatest species diversity exists in Perry's Victory Monument Marsh under the present diverse conditions of fluctuating water levels creating open water, mudflats, and surrounding unmowed lawn.

TABLE 8. Species Inhabiting the Mudflat of Perry's Victory Monument Marsh after the Water Drained when Lake Erie Lowered in Late August 1974 (Zone III, Figure 3)

A. Marsh species invading the area that was covered with water earlier in the season.

Species that were colonizing by rhizomes creeping in mostly from colonies along the edge (offshoots or rhizomlings present). Primarily species that are potentially zone-forming dominants.

Sagittaria latifolia	*Eleocharis erythropoda*
Typha angustifolia	*Scirpus validus*
Sparganium eurycarpum	*Rorippa sylvestris*
Juncus torreyi	

Species that were colonizing by the germination of seeds (seedlings present). Primarily species that are potentially scattered sub-dominants.

Cyperus esculentus	*Lindernia dubia*
Butomus umbellatus	*Alisma plantago-aquatica*
Ranunculus sceleratus	*Bidens frondosus*
Rorippa palustris	*Hibiscus moscheutos*

B. Submersed species inhabiting the area that was once covered wtih water.

Species that continued to survive on the mudflat.

Heteranthera dubia	*Butomus umbellatus*
Myriophyllum exalbescens	

Species that appeared to have died on the mudflat.

Potamogeton crispus	*Potamogeton illinoensis*
Potamogeton foliosus	

ACKNOWLEDGMENTS

Sincere appreciation is extended to the National Park Service for permission to study the flora of Perry's Victory Monument Marsh and to the following individuals for assistance in helping with the research: Drs. Carol and Jerry Baskin, Mr. Thomas Duncan, Dr. Jane L. Forsyth, Dr. James S. Pringle, Mr. Marvin L. Roberts, Dr. John W. Thieret, and the students in my class on aquatic plants.

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TABLE 9. Probable Dominant Vegetation Zones that Could be Expected as Related to the Kind of Habitat and General Water Level in Perry's Victory Monument Marsh*

Kind of Habitat	General Water Level	Growth Habit of Plants	Probable Dominant Vegetation Zones (Arranged in order from driest habitat to wettest habitat)
Lawn	Low; Dry to Damp	Emersed Plants	*Agrostis gigantea*
Lawn	Low; Dry to Damp	Emersed Plants	*Agrostis gigantea–Agrostis stolonifera–Stellaria graminea*
Lawn	Low; Dry to Damp	Emersed Plants	*Agrostis gigantea–Agrostis stolonifera–Rorippa sylvestris*
Marsh	Low; Dry to Damp / Fluctuating	Emersed Plants	*Rorippa sylvestris*
Marsh	Low; Dry to Damp / Fluctuating	Emersed Plants / Submersed and Emersed Plants	*Typha angustifolia*
Marsh	Fluctuating	Submersed and Emersed Plants	*Sagittaria latifolia*
Marsh	Fluctuating	Submersed and Emersed Plants	*Sparganium eurycarpum*
Marsh	Fluctuating	Submersed and Emersed Plants	*Sagittaria latifolia–Sparganium eurycarpum–Butomus umbellatus*
Marsh / Pond	Fluctuating / High; Standing Water	Submersed and Emersed Plants / Submersed or Floating-leaved Plants	*Butomus umbellatus*
Marsh / Pond	Fluctuating / High; Standing Water	Submersed and Emersed Plants / Submersed or Floating-leaved Plants	*Myriophyllum exalbescens–Heteranthera dubia–Potamogeton crispus–Potamogeton foliosus*
Pond	High; Standing Water	Submersed or Floating-leaved Plants	*Ceratophyllum demersum–Utricularia vulgaris–Elodea canadensis–Potamogeton pectinatus*
Pond	High; Standing Water	Submersed or Floating-leaved Plants	*Nymphaea tuberosa*

*Vertical lines "block out" the kind of habitat, general water level, and growth habit of the plants that generally correlate with each probable dominant vegetation zone.

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Nature education feature --

CHAMPION TREES OF MICHIGAN

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The Big Tree project was initiated by the Michigan Botanical Club over 20 years ago. During that period the number of national champion tree species in Michigan has increased from three to sixty native and cultivated trees. National Champions are designated by the American Forestry Association according to a point rating calculated by adding the girth (inches) at 4½ feet, the height (feet), and one-fourth of the average crown spread (feet).[1] Until a few years ago Michigan possessed more national champions than any other state in the union. However, Florida, with approximately seventy champions, now leads the nation. This leadership might be expected as over 100 native species of trees are confined to the semi-tropical section of that state that are not native to any other state in the country. State champions are based only on girth data.

The current Michigan listing includes thirty-eight species with girths esceeding 15 ft. Twelve trees possess circumferences over 20 ft. and three exceed 25 ft. in girth. The listing shows 32 trees with heights surpassing 100 ft. and eight trees exceed 125 ft. The tallest tree is a tulip-tree in Cass County with a height of 189 ft. A white pine in the Huron Mountains ranks second with a height of 186 ft; third is a Lenawee County sycamore at 157 ft. In Michigan, white pines generally show the greatest heights, with sycamores, elms, and cottonwoods also possessing exceptional heights.

As a group willows show the greatest girths; this group claims nine national champions in the state. Cottonwoods are also often very large, the state champ showing a girth of 309 inches. Oaks also rank high in trunk circumference; Michigan has six species as national champs. The maples claim five champion species for the state.

Michigan's fine record of champion trees is the result of the cooperative assistance of conservation organizations, educational groups, foresters, newspaper publicity, and that segment of the public interested in the value of trees and their preservation. Newspaper articles, especially with pictures of large trees, have been particularly effective in publicizing the Big Tree project. Most of the larger trees of each species have been marked with aluminum plaques (4 × 6 inches) showing the designation "Michigan Big Tree" and the scientific and common name of the tree.

The smaller tree species are often overlooked as potential "Big Trees." The Big Tree Committee needs more data on these species. In addition, large tree

[1]See Richard Pardo, AFA's social register of Big Trees, Am. Forests 79(4): 21-47. 1973.

records, although not equal to those of champions, should be submitted to the committee. In the past some of these have replaced former champions. Data on big trees should be sent to the committee recording secretary: Mrs. Julia Hunter, 4502 Cooper Ave., Royal Oak, Michigan 48073. Data should include the kind of tree, its girth at 4½ ft. from ground level, its location (also distance and direction from nearest town), and, if possible, the name and address of the owner and the height and spread of the tree. Requests for tree lists or information about the big tree program can be obtained by sending a self-addressed, stamped envelope to the corresponding secretaries, either Miss Mary Case or Helen Beaumont, at 8900 E. Jefferson Ave., Detroit, Michigan 48214. Other members of the Michigan Big Tree Committee are Dr. Edward G. Voss (University of Michigan), Harold Nett, J. Rehkopf, and Paul W. Thompson–Chairman (Cranbrook Institute of Science).

CHAMPION TREES OF MICHIGAN

Name of Tree	*Girth in.	Ht. ft.	Spr. ft.	County: Location of Tree	†Observer
Ailanthus *Ailanthus altissima*	139	69	63	St. Clair: Marine City–cemetery N. of M-29	HN
Alder, European *Alnus glutinosa*	72	–	–	Kent: Grand Rapids–Oakland nr. Franklin	H. Clark
Alder, speckled *A. rugosa*	*32	57	28	Ottawa: Holland–Ottawa Beach & Lk. Breeze Rd.	PT
Apple *Malus pumila*	120	38	28	Oakland: Bloomfield Twp.–5400 Lanelake Rd.	R. Rea
Apricot *Prunus armeniaca*	70	48	47	Livingston: W. of Pinckney–5856 M-36	PT
Ash, black *Fraxinus nigra*	93	67	32	Ontonagon: 5 mi. S. of Bergland–Sect. 28	S. VanBuren W. Heikkila
Ash, red *F. pennsylvanica*	171	85	91	Oakland: Berkley–2414 Columbia St.	PT
Ash, white *F. americana*	228	108	101	Lenawee: 5 Mi. N. of Adrian–Tipton Rd.	HN
Aspen, bigtooth *Populus grandidentata*	132	72	42	Manistee: 1½ mi. N. of Bear Lk–Kennedy farm	J. Calkins
Aspen, quaking *P. tremuloides*	*106	106	76	Ontonagon: Porcupine Mt. State Park–S. Boundary Rd.	HN
Bald-cypress *Taxodium distichum*	113	79	66	Ionia: Saranac–128 W. Division	PT
Basswood *Tilia americana*	*267	115	75	Grand Traverse: Old Mission Peninsula–Schoolhouse	A. Hodge
Beech, American *Fagus grandifolia*	190	76	121	Van Buren: Lawrence–end of Blackman St.	HN
Birch, mt. paper *Betula cordifolia*	*83	87	70	Leelanau: Sleeping Bear Dunes	PT

*National Champion †HN=Harold Nett; PT=Paul W. Thompson

CHAMPION TREES OF MICHIGAN (Continued)

Name of Tree	Girth in.	Ht. ft.	Spr. ft.	County: Location of Tree	Observer
Birch, white *B. papyrifera*	140	101	108	Leelanau: NE shore of Lake Leelanau	H. Harvey
Birch, yellow *B. alleghaniensis*	*178	114	101	Mackinac: 7 mi. S. of Gould City	W. Mahalak
Black-haw *Viburnum prunifolium*	17	24	17	Oakland: Swamp S. of Lakeville	PT
Bladdernut *Staphylea trifolia*	*19	36	37	Macomb: NW of Utica–Utica Rec. Area	HN & PT
Blue-beech *Carpinus caroliniana*	44	45	47	Wayne: Trenton–Elizabeth Park	HN
Box-elder *Acer Negundo*	*198	95	101	Washtenaw: NW edge Milan–Saline-Milan Rd.	HN & PT
Buckeye, Ohio *Aesculus glabra*	107	68	47	Sanilac: Lexington–5666 Main St.	HN
Buckthorn, European *Rhamnus cathartica*	*45	61	65	Washtenaw: Ann Arbor–N. of Nichols Arboretum	D. Jones & PT
Buckthorn, glossy *R. frangula*	24	35	22	Oakland: Pleasant Ridge–Pinecrest & Kemberton	PT
Butternut *Juglans cinerea*	156	80	115	Sanilac: Lexington–7225 Simions	HN
Buttonbush *Cephalanthus occidentalis*	26	29	17	Washtenaw: 2 mi. E of Clinton–US 12	PT
Catalpa, southern *Catalpa bignonioides*	184	54	58	Kent: Sparta–101 W. Division	PT
Catalpa, northern *C. speciosa*	*226	94	85	Ingham: Lansing–Capitol grounds	PT
Cedar, red *Juniperus virginiana*	90	50	42	Grand Traverse: N. of Williamsburg	H. Harvey
Cedar, white *Thuja occidentalis*	*216	113	42	Leelanau: SW corner of S. Manitou Island	PT
Cherry, black *Prunus serotina*	*285	114	93	Van Buren: N. of Lawrence–C. Sanborn res.	PT
Cherry, choke *P. virginiana*	*65	66	56	Kent: Ada–Community Park	PT
Cherry, pin *P. pensylvanica*	*47	40	30	Benzie: SW of Beulah–Joyfield Twp.	A. Tesaker
Cherry, sour *P. cerasus*	*119	68	75	Calhoun: N. of Homer–H Dr. S.	PT
Cherry, sweet *P. avium*	115	65	72	Oakland: Bloomfield Hills–Cranbrook	PT
Chestnut, American *Castanea dentata*	186	70	58	Grand Traverse: Traverse City–201 Hammond	H. & J. Hammond
Crab, prairie *Malus ioensis*	26	36	40	Oakland: Bev. Hills–Kirkshire Rd.	PT
Crab, sweet *M. coronaria*	26	28	33	Wayne: Plymouth–Haggerty & Middle Rouge	HN

CHAMPION TREES OF MICHIGAN (Continued)

Name of Tree	Girth in.	Ht. ft.	Spr. ft.	County: Location of Tree	Observer
Dogwood, flowering *Cornus florida*	53	48	50	St. Joseph: 4½ mi. W. of Burr Oak	P. Cowles
Dogwood, gray *C. racemosa*	*13	30	24	Oakland: Birmingham–231 Larchlea	PT
Dogwood, pagoda *C. alternifolia*	21	30	22	Leelanau: Empire–High Dunes	PT
Dogwood, roundleaf *C. rugosa*	*10	32	12	Leelanau: Good Harbor (Lk. Mich.)	PT
Dogwood, silky *C. purpusii*	6	11	9	Oakland: Bev. Hills–Kirkshire Rd.	PT
Elder, common *Sambucus canadensis*	*10	16	12	Leelanau: SW corner S. Manitou Is.	M. Hall; PT
Elder, redberried *S. pubens*	*18	15	13	Mackinac: Mackinac Is.–W. Bluff Rd.	PT
Elm, slippery *Ulmus rubra*	130	87	72	Lenawee: NE of Tecumseh	HN
Elm, rock *U. thomasii*	90	91	66	Grand Traverse: 5 mi. E. of Kingsley	H. Harvey
Elm, Siberian *U. pumila*	141	85	80	Oakland: Rochester–Romeo & Parkdale	HN
Elm, white *Ulmus americana*	232	125	90	Marquette: Huron Mt. Club (Big Bay)	C. Waterman; PT
Fir, balsam *Abies balsamea*	*84	116	33	Ontonagon: Porcupine Mt. State Park–Govt. Peak Trail	PT
Fringetree *Chionanthus virginica*	*24	18	25	Grand Traverse: Traverse City–St. Hospital	PT
Ginkgo *Ginkgo biloba*	125	89	66	Hillsdale: Hillsdale Library	H. Cordrey
Hackberry *Celtis occidentalis*	*235	118	104	Allegan: Wayland–10th St. & 132 Av.	G. Merren & PT
Haw, downy *Crataegus mollis*	*105	52	62	Wayne: Grosse Ile–8120 Macomb St.	PT
Haw, dotted *C. punctata*	*50	39	52	Oakland: Bloomfield Hills–Guilford Rd.	PT
Haw, fleshy *C. succulenta*	*26	42	42	Keweenaw: Delaware–Montreal River	PT
Hemlock *Tsuga canadensis*	156	113	80	Marquette: Huron Mt. Club (Big Bay)	D. Bingham & C. Gale
Horsechestnut *Aesculus hippocastanum*	163	55	64	Washtenaw: W. of Ann Arbor–10395 Jerusalem Rd.	C. Redderman
Hickory, bitternut *Carya cordiformis*	132	105	80	Cass: Marcellus–Burlington Rd., N. of M-216	L. Lewis & PT
Hickory, kingnut *C. laciniosa*	102	76	72	Washtenaw: S. of Saline–Arkona & Macon	PT
Hickory, pignut *C. glabra*	144	70	59	Ingham: 2 mi. W. of Stockbridge	HN

CHAMPION TREES OF MICHIGAN (Continued)

Name of Tree	Girth in.	Ht. ft.	Spr. ft.	County: Location of Tree	Observer
Hickory, shagbark *C. ovata*	136	76	38	Calhoun: NW of Marshall–Baker Sanctuary	H. Harvey
Holly, Michigan *Ilex verticillata*	10	17	14	Washtenaw: NW of Chelsea–Long Lake	PT
Holly, mt. *Nemopanthus mucronatus*	12	18	8	Oakland: NW of Highland–Fish Lake	PT
Hoptree *Ptelea trifoliata*	*30	31	32	Kent: Ada–Community Park	C. Rogers & PT
Ironwood *Ostrya virginiana*	79	–	–	Wexford: Sherman	A. Wooll
Juniper, common *Juniperus communis*	*17	18	8	Leelanau: Glen Haven–Sand dunes	PT
Kentucky Coffeetree *Gymnocladus dioica*	119	86	67	Lenawee: Morenci–City Park	M. Nielsen
Locust, black *Robinia pseudo-acacia*	211	72	76	Hillsdale: N. of Hudson–1334 Stewart Rd.	W. Hoppe & PT
Locust, honey *Gleditsia triacanthos*	*204	115	124	Wayne: Grosse Ile–24532 E. River Dr.	C. Bauman
Locust, thornless *G. triacanthos* f. *inermis*	145	101	81	Washtenaw: S. of Ypsilanti–8145 Stony Cr.	D. Minick
Magnolia, cucumber *Magnolia acuminata*	130	64	66	Lenawee: Adrian–225 Toledo St.	V. Anderson
Maple, black *Acer nigrum*	*174	110	108	Macomb: W. of Mt. Clemens–Clinton Riv.	HN
Maple, mt. *A. pensylvanicum*	*16	48	34	Leelanau: SW corner S. Manitou Is.	M. Hall & PT
Maple, Norway *A. platanoides*	131	–	–	Wayne: Grosse Pte. Farms–Lakeshore Dr.	HN
Maple, red *A. rubrum*	*197	125	108	Macomb: Armada–23060 Torrey	PT
Maple, silver *Acer saccharinum*	*271	125	128	Oakland: N. Rochester–405 W. Stony Cr. Rd.	HN
Maple, striped *A. pensylvanicum*	*44	59	43	Marquette: Huron Mt. Club (Big Bay)	D. Bingham, C. Gale, PT
Maple, sugar *A. saccharum*	198	113	97	Washtenaw: Ann Arbor–N. of Sunset Dr.	L. Kelly III
Mt. Ash, American *Sorbus americana*	38	67	30	Luce: Muskallonge State Park	PT
Mt. Ash, European *S. aucuparia*	58	58	35	Livingston: Howell–W. Washington & Gordon	HN
Mt. Ash, showy *S. decora*	*57	58	32	Mackinac: 7 mi. S. of Gould City	W. Mahalak
Mulberry, red *Morus rubra*	178	79	84	Lenawee: Adrian–3787 N. M-52	PT
Mulberry, white *M. alba*	*201	77	74	St. Joseph: W. of 3 Rivers–Bullock nr. Ruggles	J. Hunter, HN, PT

CHAMPION TREES OF MICHIGAN (Continued)

Name of Tree	Girth in.	Ht. ft.	Spr. ft.	County: Location of Tree	Observer
Nannyberry *Viburnum lentago*	25	18	28	Oakland: Bloomfield Hills–D. Draper res.	PT
Oak, Bebb-× *Quercus ×bebbiana*	*155	88	108	Kalamazoo: SE of Augusta–Ft. Custer	PT
Oak, black *Q. velutina*	210	115	124	St. Clair: Algonac–Clay & Washington	HN
Oak, bottom-× *Q. ×runcinata*	45	75	46	Washtenaw: Ann Arbor–Tubbs at Huron Riv.	W. H. Wagner & PT
Oak, bur *Q. macrocarpa*	*251	128	108	St. Clair: Algonac–350 N. Parkway	J. Laurie & PT
Oak, chestnut *Q. muhlenbergii*	190	91	84	Genesee: Grand Blanc–Grand Blanc Rd. nr. US-23	PT
Oak, English *Q. robur*	77	68	70	Grand Traverse: Traverse City–St. Hospital	PT
Oak, Jack-× *Q. ×jackiana*	*225	86	118	Shiawassee: W. of Durand–Bancroft nr. Newberg Rd.	W. Bronson & PT
Oak, N. pin *Q. ellipsoidalis*	*137	85	86	Oakland: SE of Lake Orion–Bald Mt. Rd.	PT
Oak, pin *Q. palustris*	157	–	–	Allegan: Otsego–North & Chelsea Sts.	HN
Oak, red *Q. rubra*	*279	118	128	Berrien: 1 mi. S. of Riverside–Maple Ln.	C. Weber, G. Terry, PT
Oak, scarlet *Q. coccinea*	179	90	94	Kalamazoo: Vicksburg	F. McLinden & F. Rapp
Oak, Schuette-× *Q. ×schuettei*	*225	114	120	Oakland: N. of Rochester–Rush & & Letts Sts.	Sturman & PT
Oak, shingle *Q. imbricaria*	148	88	92	Branch: N. of Coldwater–Calkins Rd.	PT
Oak, swamp *Q. bicolor*	204	96	80	Washtenaw: E. of Ann Arbor–Dresland & Stammel	Kelly
Oak, white *Q. alba*	216	106	113	Allegan: SW Allegan–Ely & 32 St.	HN
Olive, Russian *Elaeagnus angustifolia*	49	41	50	Oakland: Birmingham–Lincoln nr. Bates	PT
Osage-orange *Maclura pomifera*	168	50	45	Berrien: Coloma	C. Nelson
Pawpaw *Asimina triloba*	32	42	32	Macomb: S. of Utica–Dodge Park #8	PT
Pear *Pyrus communis*	*136	51	50	Oakland: Clawson–1034 Crooks Rd.	PT
Persimmon *Diospyros virginiana*	60	51	39	Kent: Grand Rapids–1715 N. Center St.	H. Clark
Pine, jack *Pinus banksiana*	85	57	47	Marquette: Yellow Dog plains	J. Wells & PT
Pine, red *P. resinosa*	117	112	64	Gogebic: Watersmeet–Sylvania–Loon Lk.	M. Lefler

CHAMPION TREES OF MICHIGAN (Continued)

Name of Tree	Girth in.	Ht. ft.	Spr. ft.	County: Location of Tree	Observer
Pine, Scotch *P. sylvestris*	*177	63	75	Lenawee: Sand Creek–Sand Creek Rd.	HN & PT
Pine, white *P. strobus*	*209	158	78	Ontonagon: Porcupine Mt. State Park–Little Carp River	W. Koser, PT, E. Pantillon
Pine, white *P. strobus*	231	108	46	Keweenaw: Copper Harbor–Estivant Pines	J. Rork & PT
Plum, American *Prunus americana*	*36	35	35	Oakland: S. of Lakeville–Rochester Rd.	PT
Plum, Canada *P. nigra*	*50	51	49	Macomb: S. of Utica–Dodge Park #8	PT
Poplar, balsam *Populus balsamifera*	133	87	56	Marquette: between Princeton & Quinn–nr. M-35	HN
Poplar, cottonwood *P. deltoides*	309	137	129	Wayne: Wayne–nr. Michigan & Josephine	F. Walker & PT
Poplar, Lombardy *P. nigra* v. *italica*	186	73	37	Chippewa: Sault St. Marie–Bingham & Easterday	HN
Poplar, silver *P. alba*	228	86	112	Charlevoix: Charlevoix	PT
Prickly-ash *Zanthoxylum americanum*	*10	12	17	Wayne: Northville–Cass Benton Park	HN
Redbud *Cercis canadensis*	58	33	29	Wayne: S. of Belleville–Lower Huron Park	HN
Sassafras *Sassafras albidum*	164	62	73	Allegan: NE of Allegan–120th Av. nr. 20th St.	C. Draper
Shadbush, Alleghany *Amelanchier laevis*	56	56	57	Cass: Marcellus–Burlington Rd.	L. Lewis & PT
Shadbush, downy *A. arborea*	41	59	46	Oakland: NW of Utica–Utica Recr. Area	PT
Shadbush, roundleaf *A. sanguinea*	*16	38	20	Keweenaw: Copper Harbor–Ft. Wilkins	PT
Smoketree *Cotinus obovatus*	15	–	–	Oakland: Orchard Lake–Apple Is.	PT
Spindle tree *Euonymus europaeus*	*19	27	20	Wayne: Inkster–Inkster Park–Lower Huron Park	HN
Spruce, black *Picea mariana*	54	57	34	Isabella: S. of Farwell–S. of Herrick Rd.	Audubon
Spruce, Norway *P. abies*	*130	74	67	Oakland: Novi–21937 Novi Rd.	PT
Spruce, white *P. glauca*	*131	103	36	Luce: 15 mi. N. of Newberry	L. Rubick & PT
Strawberry-bush *Euonymus americanus*	10	16	12	Oakland: NW of Utica–Utica Recr. Area	PT
Sumac, shining *Rhus copallina*	20	20	12	Kalamazoo: Vicksburg	F. McLinden
Sumac, poison *Rhus vernix*	15	31	30	Oakland: Swamp S. of Lakeville	PT

CHAMPION TREES OF MICHIGAN (Continued)

Name of Tree	Girth in.	Ht. ft.	Spr. ft.	County: Location of Tree	Observer
Sumac, smooth *R. glabra*	15	30	19	Washtenaw: N. of Dexter–Strawberry Rd.	PT
Sumac, staghorn *R. typhina*	*29	49	30	Oakland: Orchard Lake–Apple Is.	PT
Sweetgum *Liquidambar styraciflua*	94	72	67	Wayne: Detroit–Fort & Woodmere	HN
Sycamore *Platanus occidentalis*	278	157	136	Lenawee: Adrian–N. of City Park	HN & PT
Tamarack, American *Larix laricina*	105	66	63	Lake: 1 mi. E. of Luther	J. Beurge
Tamarack, European *L. decidua*	103	80	70	Branch: Coldwater–RR. nr. Jay St.	HN
Tulip-tree *Liriodendron tulipifera*	237	189	112	Cass: 10 mi. E. of Dowagiac–Russ Forest	PT
Tupelo *Nyssa sylvatica*	140	77	80	Cass: Marcellus–Wright & Burlington	L. Lewis
Walnut, black *Juglans nigra*	222	102	95	Macomb: W. of New Haven–56505 Omo Rd.	H. Hinz
Willow, balsam *Salix pyrifolia*	*11	15	7	Chippewa: Sugar Is. nr. Soo	J. Hiltunen
Willow, Bebb *S. bebbiana*	*18	37	12	Leelanau: SE of Maple City–Cedar Run Cr.	PT
Willow, black *S. nigra*	*337	90	96	Grand Traverse: Traverse City–S. of St. Hosp.	H. Harvey
Willow, brittle *S. fragilis*	*298	112	116	Macomb: NW of Utica–Utica Recr. Area	R. Erwin & PT
Willow, purple *S. purpurea*	*15	37	49	Leelanau: W. of Omena–Putnam & C-629	PT
Willow, pussy *S. discolor*	23	26	30	Washtenaw: W. of Ann Arbor–Waters Rd. nr. Fletcher	HN
Willow, sandbar *S. interior*	*20	37	13	Macomb: N. of Utica–Utica Recr. Area	PT
Willow, shining *S. lucida*	*90	60	58	Grand Traverse: Traverse City–St. Hospital	PT
Willow, weeping *S. babylonica*	*249	106	114	Wayne: Detroit–886 Ashland St.	M. Kropp
Willow, white *S. alba*	*343	83	132	Jackson: W. of Jackson–Blackman Rd.	PT
Witch-hazel *Hamamelis virginiana*	*17	43	41	Muskegon: Muskegon State Park	PT
Yellowwood *Cladrastis lutea*	97	75	73	Livingston: Howell–Center & Grand Riv.	HN

Editorial Notes

BACK ISSUES NEEDED: We could make up more complete sets of back issues for new institutional (and other) subscribers if we could obtain certain scarce back issues. Readers having no further need for the following are invited to return them for "recycling": Both numbers of Vol. 1 (1962); Vol. 2, No. 1 (January 1963); Vol. 4, No. 3 (May 1965); Vol. 5, No. 1 (January 1966); Vol. 5, No. 3A (May 1966–supplement). We will gladly refund postage, upon request, for copies of *these numbers* returned (use transient second class or library rate).

SETS AVAILABLE: There are still some complete sets of back issues available. Volumes 1-13, complete, are priced at $29.25 plus postage. Volumes 2-13, at $27.00 plus postage. When these are gone, available sets will lack one or more of the issues listed in the preceding paragraph. Send all orders to the business and circulation manager.

SPECIAL PUBLICATION No. 3 of the Michigan Botanical Club will be a reprint, with special covers, of the Pictured Rocks flora by Robert Read which appeared in our January 1975 number. This should be ready very soon. Single copies will be available at $1.25 postpaid from the Michigan Botanical Club, c/o Herbarium, North University Bldg., The University of Michigan, Ann Arbor, Michigan 48104. The same quantity discount rates will apply as for previous numbers in the Special Publication series.

ERRATUM: In the March issue, Vol. 14, No. 2, p. 104, line 5 from bottom, for *douglasii* read *sanguineus*.

The March number (Vol. 14, No. 2) was mailed April 4, 1975.

Publications of Interest

BARTLETTIA. Notes from the Matthaei Botanical Gardens of The University of Michigan. This new series of leaflets honors in its title Harley Harris Bartlett (1886-1960), Director of the Gardens 1916-1956. The 8-page No. 1, "A Collection of Minor Bulbs at the Botanical Gardens," by Merle M. Moore, Chief Horticulturist, was issued March 26, 1975.

The following new publications of the Ohio Biological Survey are available from OSU University Publications Sales, Room 20 Lord Hall, 124 W. 17th Ave., Columbus, Ohio 43210. Include 10% of the costs of publications for postage, and make checks payable to Ohio Biological Survey.

THE NATURAL AREAS PROJECT. A Summary of Data to Date. By J. Arthur Herrick. Ohio Biol. Surv. Informative Circ. 1 (revised). 1974. 60 pp. $1.00. Published in cooperation with The Nature Conservancy, this directory of 579 Natural Areas in Ohio is organized by county and includes a brief general history of natural areas work in Ohio, which has been an unusually active state in this regard.

AN ECOLOGICAL AND TAXONOMIC STUDY OF SELECTED HIGHER FUNGI IN NORTHEASTERN OHIO. By William G. Cibula. Ohio Biol. Surv. Biol. Notes 7. 1974. 95 pp. $3.50. Copiously illustrated with excellent photographs, this work presents full descriptions of 32 species, with special reference to microclimatic environments in which they grow in Geauga County, Ohio.

RIVER BIRCH (BETULA NIGRA L.) COMMUNITIES OF SOUTHEASTERN OHIO. By Larry D. Cribben and Irwin A. Ungar. Ohio Biol. Surv. Biol. Notes 8. 1974. 37 pp. $1.75. A study in floodplain forests of the unglaciated area of southeastern Ohio, where distribution of river birch is closely related to acid mine drainage into streams.

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(On the cover: The common trillium, Trillium grandiflorum, *photographed at Portage, Michigan (Kalamazoo County), by Julie Medlin, May 14, 1974.)*

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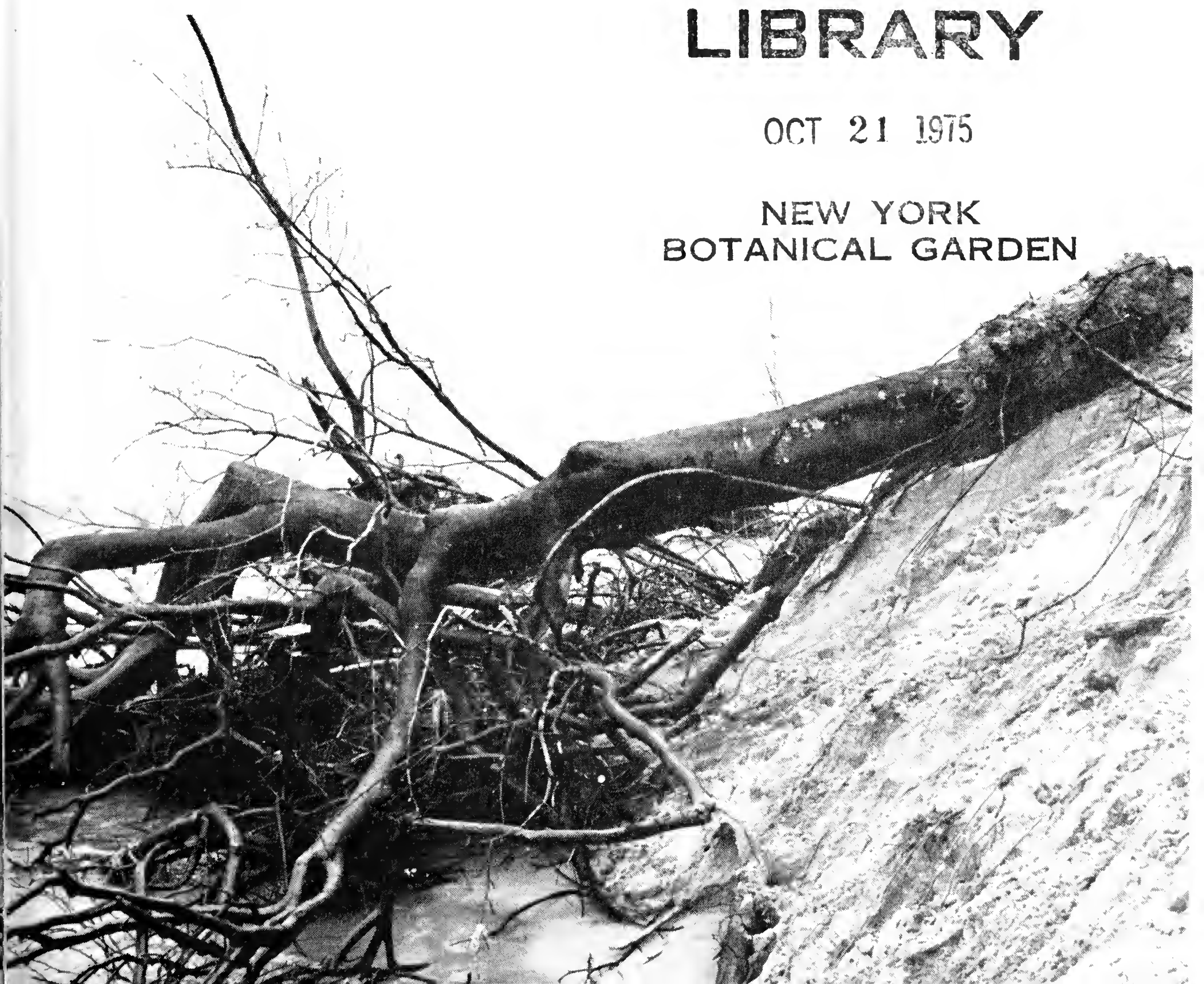
THE MICHIGAN BOTANIST

October, 1975



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Address changes from Botanical Club members should be sent only to appropriate chapter officers. Address changes for *non-member subscribers only* should be sent to the business and circulation manager. Send *no* address changes to the editor.

Articles dealing with any phase of botany relating to the Upper Great Lakes Region may be sent to the editor in chief. In preparing manuscripts, authors are requested to follow our style and the suggestions in "Information for Authors" (Vol. 13, p. 190).

THE MICHIGAN BOTANICAL CLUB

Membership in the Michigan Botanical Club is open to anyone interested in its aims: conservation of all native plants; education of the public to appreciate and preserve plant life; sponsorship of research and publication on the plant life of the State; sponsorship of legislation to promote the preservation of Michigan native flora and to establish suitable sanctuaries and natural areas; and cooperation in programs concerned with the wise use and conservation of all natural resources and scenic features.

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SCANNING ELECTRON MICROSCOPY OF SPORE ORNAMENTATION IN THE GENUS *LACTARIUS*

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INTRODUCTION

Smith and Hesler (1962), Shaffer (1962), and Romagnesi (1967) in their taxonomic work on taxa of the Russulaceae stressed the importance of spore morphology in this family. Only the light microscope was used in their studies. Pegler and Young (1971) reviewed the work on basidiospore morphology in the Agaricales and pointed out that observations on many species are incomplete.

The light microscope shows the family Russulaceae to have basidiospores with amyloid ornamentation. However, the clarity of surface detail of spores is limited by the resolving power of this microscope. The additional magnification and resolution possible with the SEM leaves no doubt about the features of the spore surface previously suggested by the light microscope.

Using the SEM, Moore and Grand (1970) and Grand and Moore (1970) showed the importance of spore morphology in a number of basidiomycete families including the Russulaceae. They have shown many features of basidiospore walls that are not obvious with the light microscope. In another publication (1971) they specifically showed the importance of the SEM in showing spore detail of various species in the Strobilomycetaceae. Bigelow and Rowley (1968), using the carbon surface replica technique, showed the value of spore ornamentation in comparing certain species in the Tricholomataceae.

The genus *Lactarius*, a member of the Russulaceae, has spores with a great variety of ornamentation patterns. Although there is some variation in ornamentation within a collection and even within a single basidiocarp, patterns are sufficiently constant within a species to be of taxonomic importance. Basidiospores of eight North American *Lactarius* are described here employing light and scanning electron microscopy. Similarities and differences of surface features among these species are discussed in relation to the taxonomy of the genus.

MATERIALS AND METHODS

Spores were obtained for SEM by allowing basidiocarps to drop spores on double-faced cellophane tape on metal SEM discs, or the double-faced cellophane tape was touched to a freshly deposited spore print. No special treatment was used to prevent spores from collapsing on drying. Spores were coated with 200 to 250 Å of gold. All material was examined and photographed with a Stereoscan S-4 scanning electron microscope (SEM).

Spores were also mounted in Melzer's reagent and observed under oil immersion with a Zeiss light microscope. The magnification was 1,250×. Spore size and shape are given as seen in lateral view. Measurements of spores exclude the ornamentation (given separately in descriptions) and hilar appendix. Drawings were traced from SEM photomicrographs.

Most of the specimens used in this study are deposited in the mycological herbarium at the University of Maine, Orono, Maine. Some, or parts of collections, were sent to Dr. A. H. Smith at the University of Michigan for identification or confirmation. These are deposited in the Herbarium of the University of Michigan, and in "collections cited" are followed by the designation (MICH). Collections without any herbarium designation are deposited in the herbarium of the University of Maine.

SPORE DESCRIPTIONS AND DISCUSSION

1. *Lactarius subvellereus* Pk. var. *subvellereus* Figs. 1 & 16

Spores 8.2-10.8 × 6.1-7.7 μ, mostly broadly elliptic, others more variable in shape from obovate to broadly obovate to ovate, some even pip-shaped. Ornamentation of many isolated warts, few fine short ridges and connectives up to 0.25-0.3 μ high (some spores smooth in optical section at 1,250× magnification), usually not forming even a partial reticulum, amyloid. Suprahilar area with low uneven diffuse ornamentation.

Collections studied: Maine: Penobscot Co.: University Forest on College Ave., Old Town, 10 Sept. 1970, Homola 3958; near Baker Brook, County Rd., Milford, 14 Aug. 1973, Homola 5589 (MICH).

The least ornamented spore found so far in the genus *Lactarius* is that of *L. subvellereus*. Under the light microscope and stained with Melzer's reagent, the spores show at most slightly raised projections with only a few connectives. The SEM photomicrographs show the spores to have very low projections with many partial ridges and connectives giving a rugose appearance to the spore, reminding one of a *Cortinarius* spore. Because not all the ridges stain with Melzer's, the spore does not exhibit the rugose appearance under the light microscope.

Singer (1962) includes in section *Albati* (Bat.) Sing., *L. subvellereus, L. vellereus* (Fr.) Fr., *L. piperatus* (L. ex Fr.) S. F. Gray, and *L. deceptivus* Pk. Pegler and Young (1971) and Grand and Moore (1970) show the spore ornamentation of *L. piperatus* to be similar to *L. subvellereus*. Kauffman (1918) reported the spores of *L. vellereus* as being nearly smooth. One might expect the spore ornamentation of *L. vellereus* to be similar to that of *L. subvellereus* though the former species has not been studied using SEM. *L. deceptivus* has a distinctly different spore ornamentation and will be discussed separately. The pattern of spore ornamentation demonstrated by *L. subvellereus* is not common in *Lactarius* to judge from the species studied to date.

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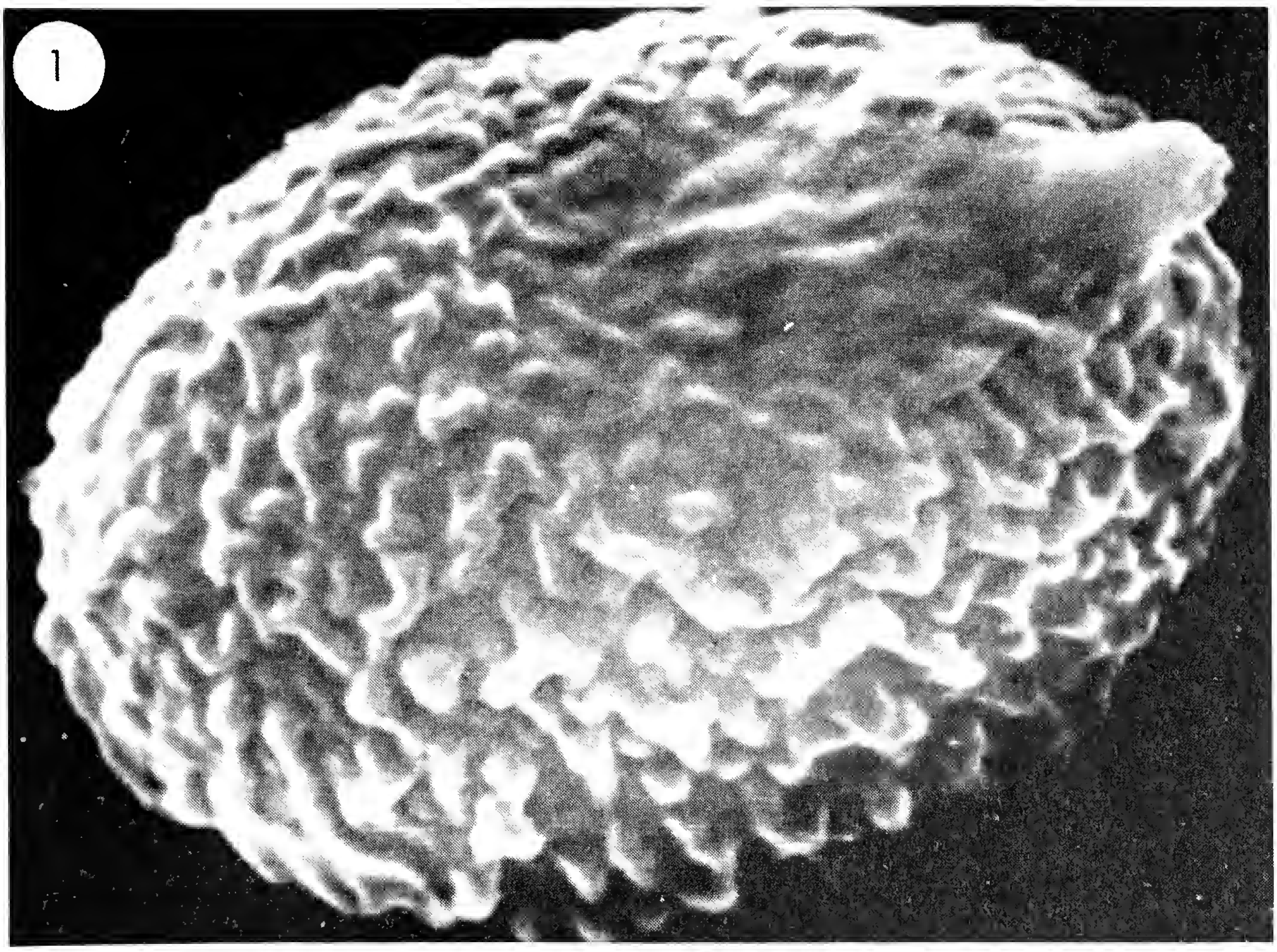
Figs. 1-2. Scanning electron micrographs of *Lactarius* spores. 1. *L. subvellereus* var. *subvellereus*, ca. 12,300×. (Homola 5589). 2. *L. deceptivus*, ca. 10,600×. (Homola 5588).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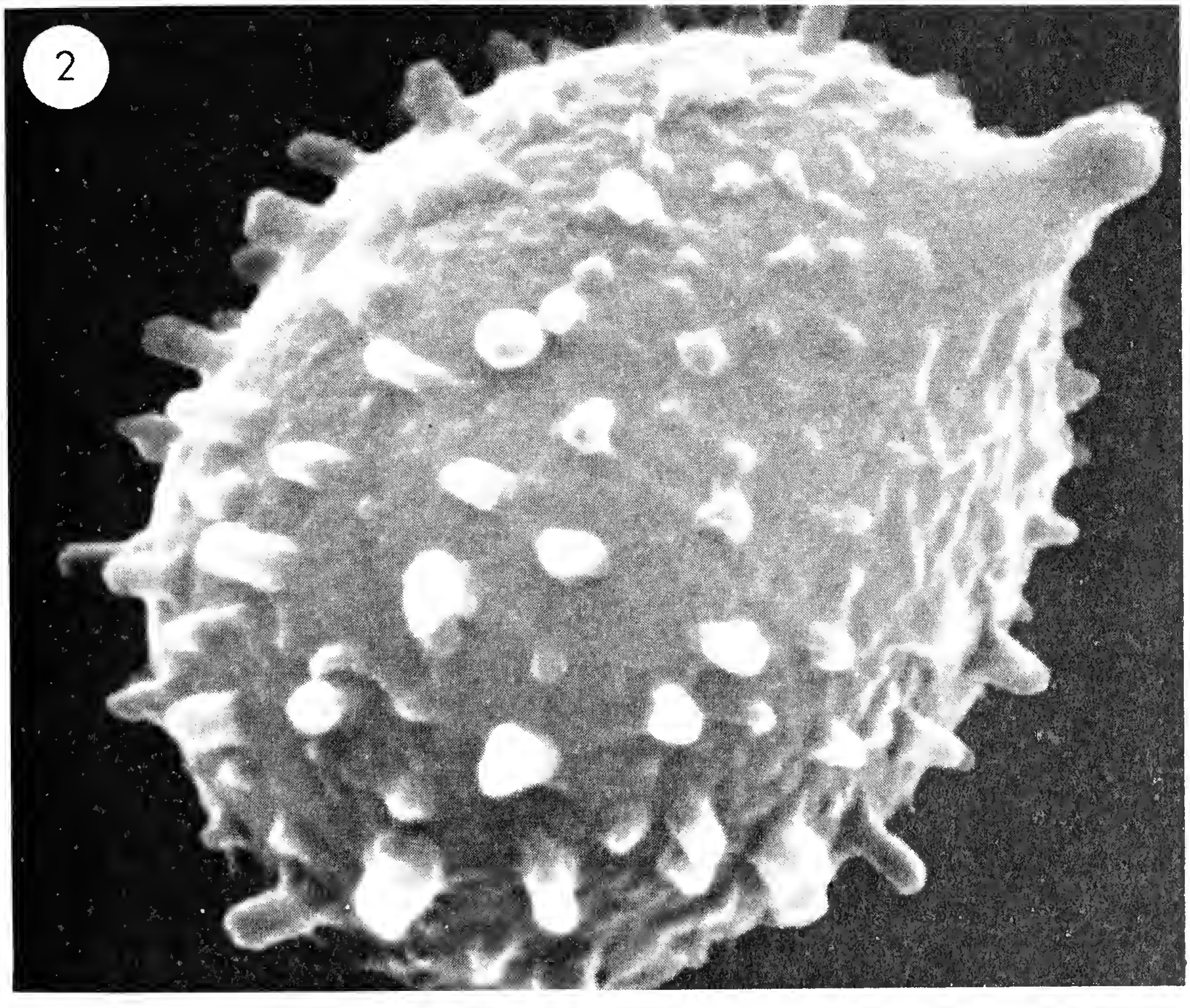
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2. *Lactarius deceptivus* Pk. Figs. 2 & 15

Spores 8.7-10.8 x 7.2-7.7 μ, broadly ellipsoid to broadly ovate to subglobose. Ornamentation of blunt, isolated, cylindric to conic warts up to 0.77-2.0 μ high, with only an occasional slight ridge, never forming even a slight reticulum, amyloid. Suprahilar area with low, uneven, diffuse ornamentation diffusely amyloid.

Collections studied: Maine: Penobscot Co.: near Baker Brook, County Rd., Milford, 9 July 1971, Homola 4960, and 14 Aug. 1973, Homola 5588 (MICH).

L. deceptivus has isolated blunt projections on the spore surface. Kauffman (1918) reported spores as echinulate. The projections are not acute like those found on most spores of *Laccaria* species, which are properly described as echinulate. The type of ornamentation found in *L. deceptivus*, apparently, is not common in the genus. On the basis of spore ornamentation alone *L. deceptivus* would seem to belong to a different section than *L. subvellereus*.

3. *Lactarius gerardii* Pk. Figs. 4 & 12

Spores 7.2-8.7 x 5.6-6.6 μ, with an occasional giant spore 10.3 x 7.2 μ, broadly ellipsoid to subglobose rarely globose. Ornamentation of blunt, cylindric to conic warts and ridges up to 0.31-0.76 μ (on giant spores 1 μ high), mostly with numerous connectives and forming a partial or more frequently a complete pentagonal meshed reticulum, amyloid. Suprahilar area usually with very low, uneven, diffuse, partly diffusely amyloid ornamentation.

Collections studied: Maine: Penobscot Co.: near Baker Brook, County Rd., Milford, 13 July 1974, Homola 5937. Michigan: Luce Co.: Tahquamenon Falls State Park, 13 Aug. 1965, Homola A3450.

L. gerardii demonstrates the most common type of spore ornamentation in the genus. The blunt warts are joined by connectives forming an almost complete reticulum. The mesh of the network is mostly five-sided.

4. *Lactarius volemus* (Fr.) Fr. Figs. 3 & 14

Spores 7.2-8.2 x 7.2-7.7 μ, occasionally broadly ellipsoid, mostly subglobose to globose. Ornamentation of blunt, cylindric projections and ridges up to 0.77-1 μ high, with an occasional giant spore 9.2 x 8.2 μ; the ridges and connectives forming an irregular, coarse, occasionally partial or more frequently a complete pentagonal meshed reticulum; amyloid. Suprahilar area with low, uneven, diffuse ornamentation, only a portion of which may be diffusely amyloid; apiculus non-amyloid.

Collections studied: Pennsylvania: Carbon Co.: near Bowmanstown, 27 Aug. 1974, Homola 6002.

L. volemus, like *L. gerardii*, has a strongly reticulate spore surface. The ridges and connectives are higher and the reticulum more complete than in the spores of *L. gerardii*. Even though the spore ornamentation is quite similar in

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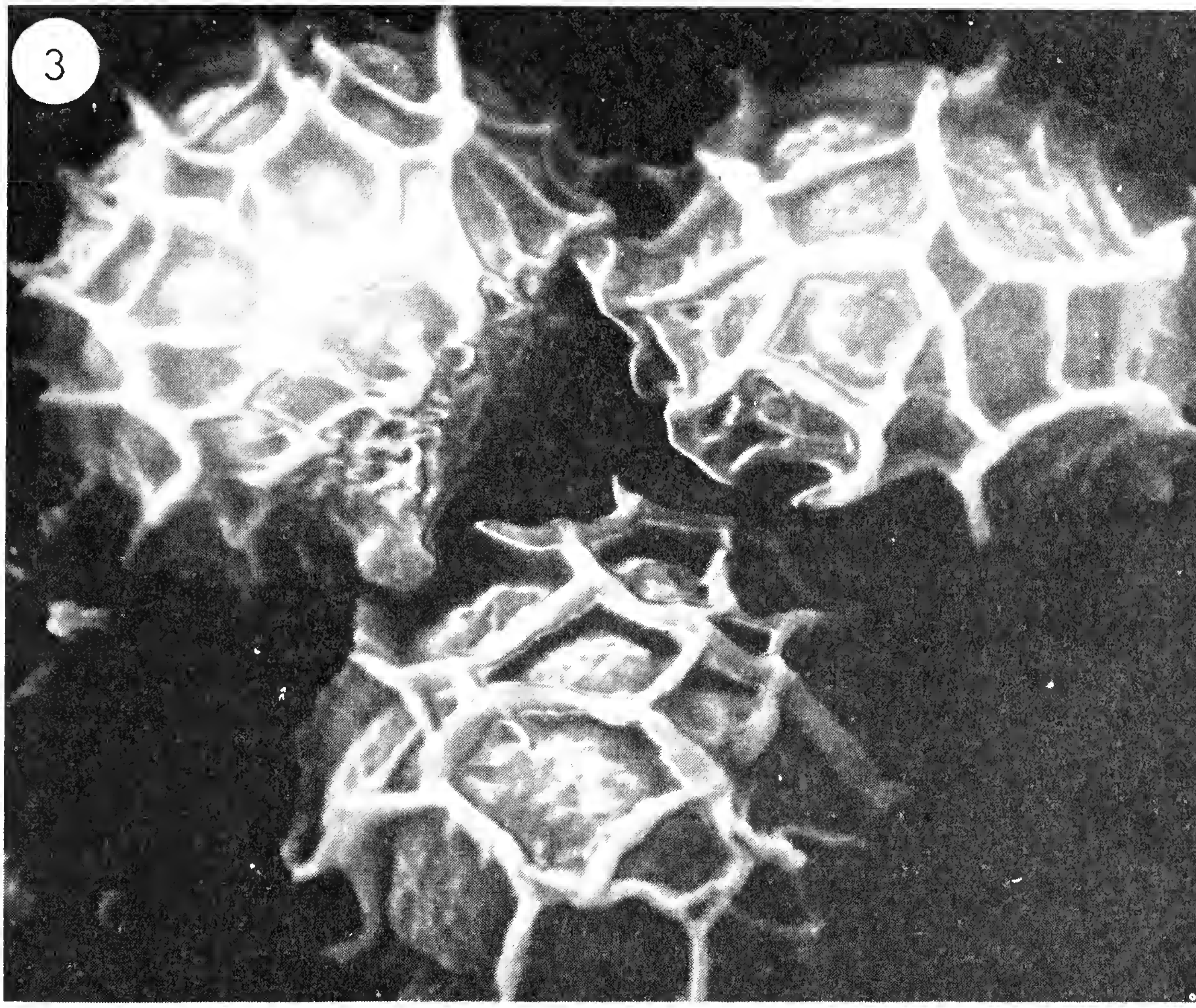
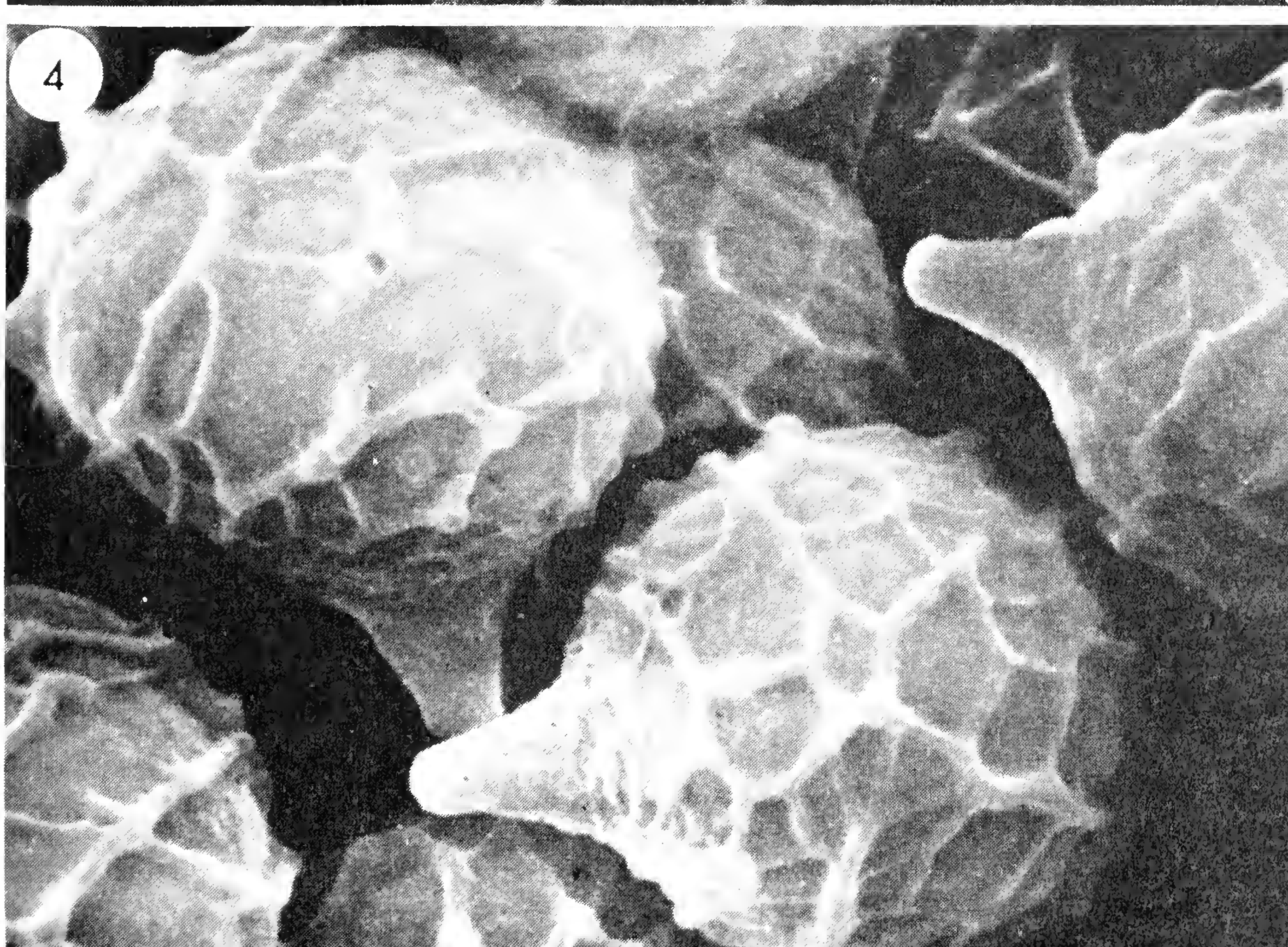
Figs. 3-4. Scanning electron micrographs of *Lactarius* spores. 3. *L. volemus*, ca. 7,000×. (Homola 6002). 4. *L. gerardii*, ca. 5,300×. (Homola 5937).





these two species, they are placed in different sections: *L. volemus* in section *Dulces* Heim by Singer (1962) and *L. gerardii* in section *Plinthogali* (Burl.) Singer.

5. *Lactarius vinaceorufescens* Smith var. *fallax* Hesler & Smith Figs. 5 & 13

Spores 7.2-8.2 × 5.6-6.0 μ, broadly ellipsoid to obovate. Ornamentation of coarse, blunt, cylindric to conic projections and ridges up to 0.75-1 μ high, coarse connectives forming in general a partial reticulum, many isolated warts also present, amyloid. Suprahilar area with low, uneven, diffuse ornamentation, often diffusely amyloid.

Collections studied: Maine: Penobscot Co.: University Forest on campus, Orono, 27 Sept. 1969, Homola 3336, and near Baker Brook, County Rd., Milford, 14 Aug. 1973, Homola 55591 (MICH in part).

Lactarius vinaceorufescens var. *fallax* has spores with a coarse ornamentation of irregular isolated warts and high irregular ridges which make the reticulum less obvious than in other species such as *L. volemus.* It approaches the winged type as seen in *L. nigroviolescens.*

6. *Lactarius trivialis* Fries sensu Kauffman, Agar. Mich. p. 100 Figs. 6 & 11

Spores 7.7-9.7 × 6.6-7.2 μ, broadly ellipsoid to ovate. Ornamentation of blunt, cylindric to conic projections and ridges up to 0.77-1 μ high, many isolated warts present, connectives forming an incomplete reticulum with small meshes, amyloid. Suprahilar area smooth or with a very low uneven diffuse ornamentation forming an irregular breastbone-shaped figure which may or may not be amyloid.

Collections studied: Maine: Penobscot Co.: near Baker Brook, County Rd., Milford, 9 July 1971, Homola 4971 and 31 July 1974, Homola 5939.

L. trivialis has surface ornamentation similar to that of *L. vinaceorufescens* var. *fallax*. It would be difficult to distinguish between the two species on the basis of spore ornamentation.

7. *Lactarius nigroviolescens* Atkinson in Burlingham
var. *marginatus* Smith & Hesler Figs. 7 & 10

Spores 8.2-9.5 × 7.2-8.7 μ, subglobose to globose. Ornamentation of curved, long cylindric to conic projections and ridges up to 1-2 μ high, the ridges and connectives forming an irregular coarse partial to complete reticulum, the whole forming a winged rather confused type of ornamentation, amyloid. Suprahilar area with low uneven diffuse ornamentation which is usually thicker near the margin of the area and forms an irregular breastbone-shaped figure a portion of which may be diffusely amyloid, near the apiculus non-amyloid.

Collections studied: Maine: Penobscot Co.: near Baker Brook, County Rd., Milford, 23 Aug. 1967, Homola 2420, 14 Aug. 1973, Homola 5587 (MICH), and 16 Aug. 1973, Homola A5617.

L. nigroviolescens var. *marginatus* has high ridges and connectives equalling the height of the projections. This gives a wing-like appearance to

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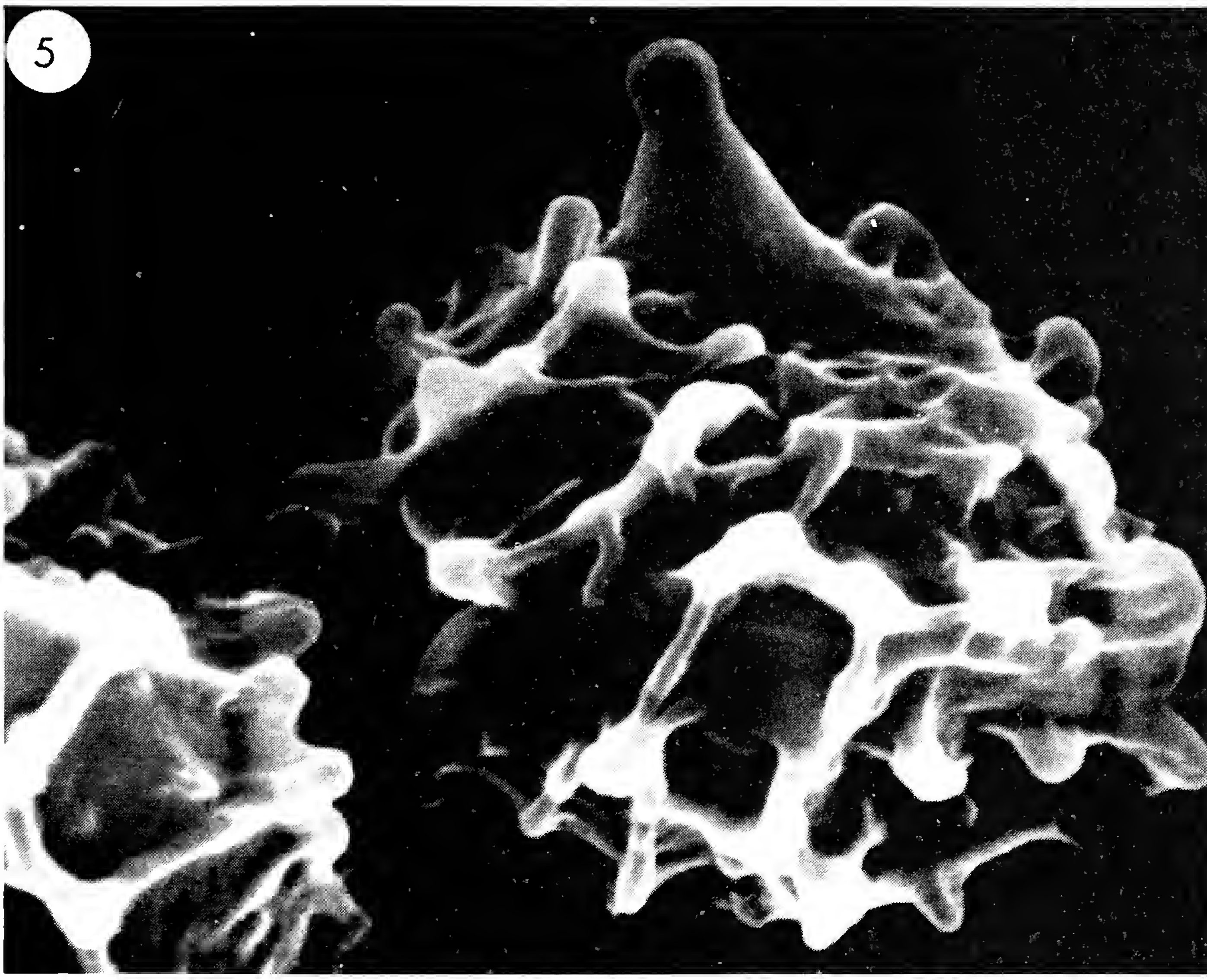
Figs. 5-6. Scanning electron micrographs of *Lactarius* spores. 5. *L. vinaceorufescens* var. *fallax*, ca. 11,900×. (Homola 5591). 6. *L. trivialis*, ca. 11,300×. (Homola 5939).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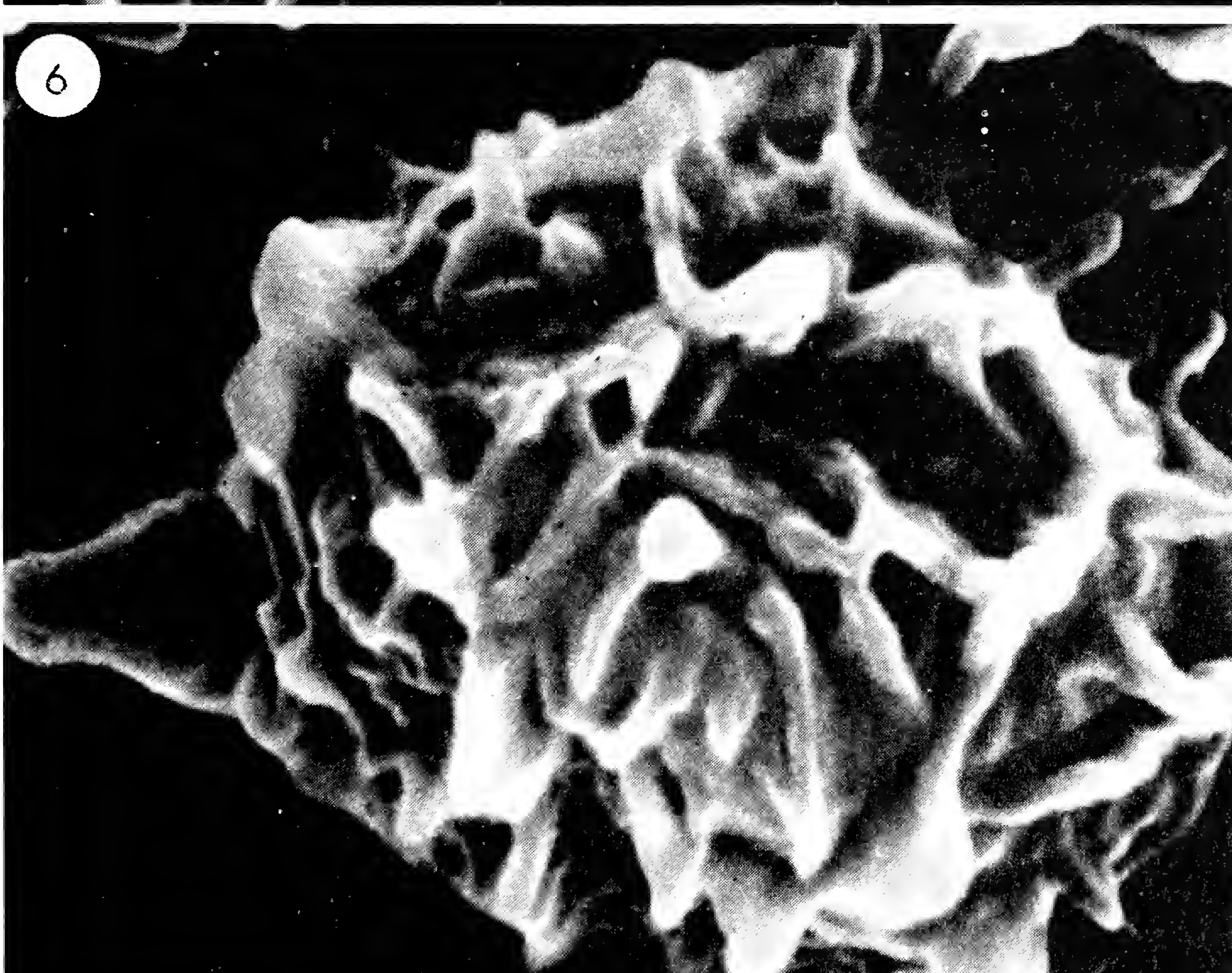
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the ornamentation. In this type of ornamentation the reticulate aspect is somewhat obscured because of the height of the ridges and the closeness of the various elements. Smith and Hesler (1962) placed *L. nigroviolescens* in section *Plinthogali* (Burl.) Singer. *L. gerardii* has a recognizably different spore ornamentation (compare the figures).

8. *Lactarius pyrogalus* Fr. Figs. 8 & 9

Spores 5.6-8.2 × 5.6-6.1 μ, with an occasional giant spore 9.5 × 7 μ, ellipsoid to subglobose, at times globose. Ornamentation of transversely crowded ridges or plates arranged ± parallel (little unornamented surface visible); ridges or plates crescent shaped, their surface uneven, slightly broader toward base and extending approximately half the width of the spore; occasional cylindric to conic warts up to 0.51-1 μ high also present; no reticulum present; amyloid. Suprahilar area small, with low uneven diffuse ornamentation.

Collections studied: Pennsylvania: Northampton Co.: near Twin Lakes, 28 Aug. 1974, Homola 5998 (MICH).

A bizarre and easily recognizable type of spore ornamentation is demonstrated by *L. pyrogalus*. Under the light microscope and stained with Melzer's, the spore ornamentation appears as coarse lines encircling the spores. Some European mycologists refer to this type of ornamentation as "zebra like," which describes it well. Under the SEM it reminds one somewhat of a snail shell.

SUMMARY

Basically, five types of spore ornamentation have been found in *Lactarius* to date: (1) rugose type, found in *L. subvellereus*; (2) tuberculate to echinulate type as shown by *L. deceptivus*; (3) reticulate type, as shown by *L. volemus* and *L. gerardii*; (4) winged type, as seen on *L. nigroviolescens*; and (5) the zebroid type demonstrated by *L. pyrogalus*. In the species studied to date the reticulate type occurs most frequently, and shows the greatest variation. *L. trivialis* and *L. vinaceorufescens* show intermediate conditions between the reticulate and winged types. This study indicates that the pattern of spore ornamentation as viewed under the scanning electron microscope is indeed significant in the delimitation of species in *Lactarius*.

ACKNOWLEDGMENTS

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We would like to thank Dr. Alexander H. Smith, University of Michigan Herbarium, for confirmation and the identification of a number of *Lactarius* collections which were sent to him, and for reading the manuscript.

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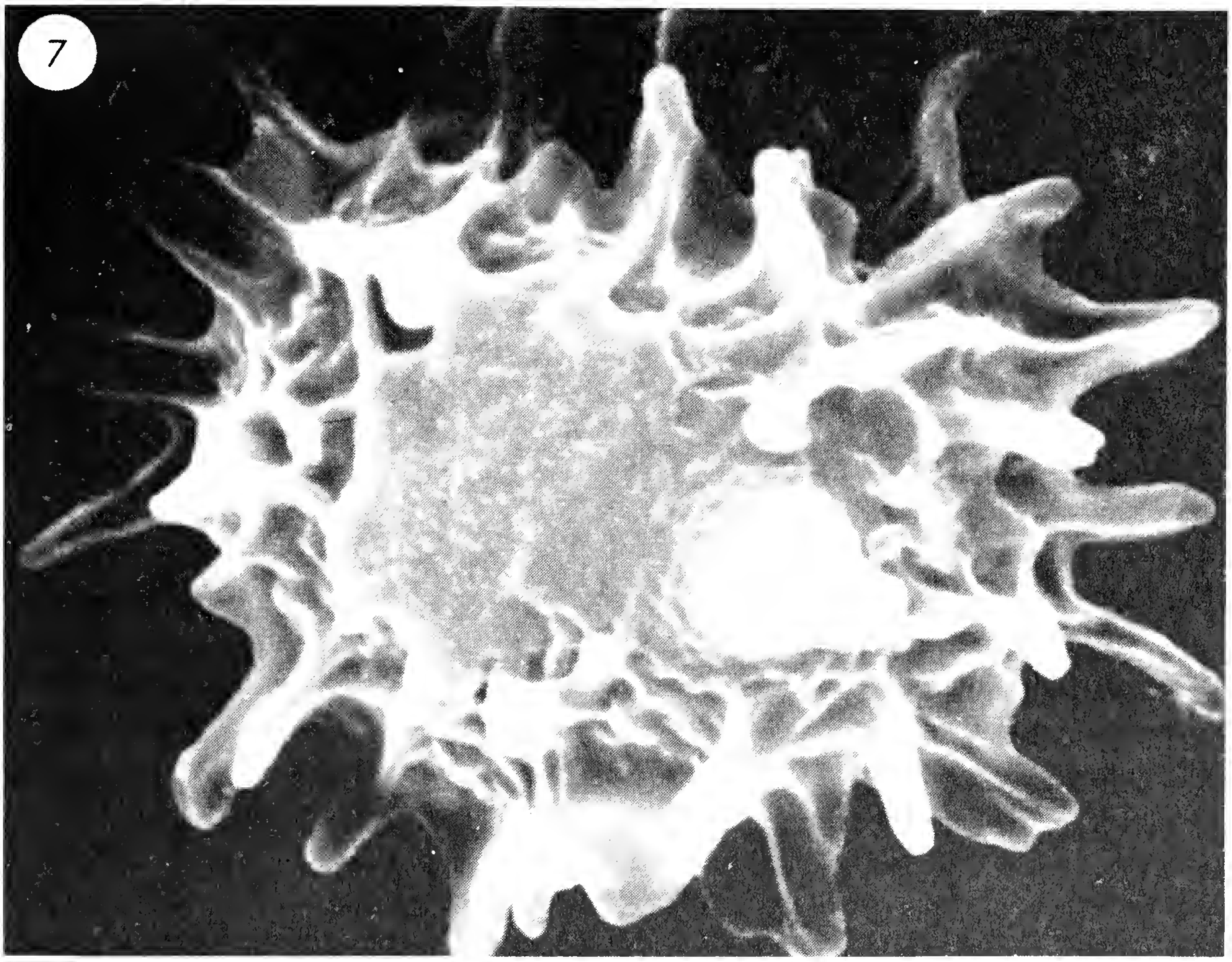
Figs. 7-8. Scanning electron micrographs of *Lactarius* spores. 7. *L. nigroviolescens* var. *marginatus*, ca. 10,500×. (Homola 5617). 8. *L. pyrogalus*, ca. 11,400×. (Homola 5998).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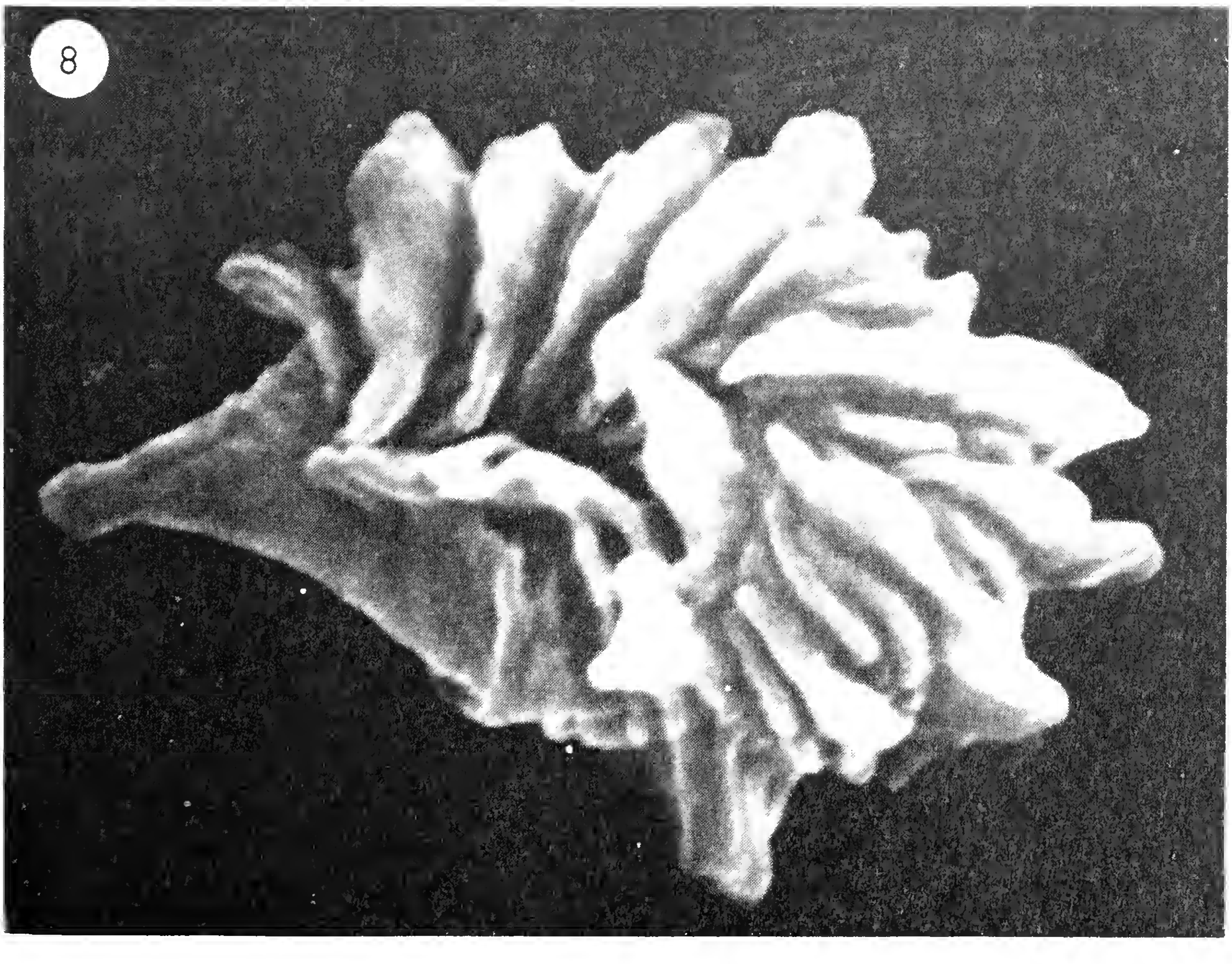
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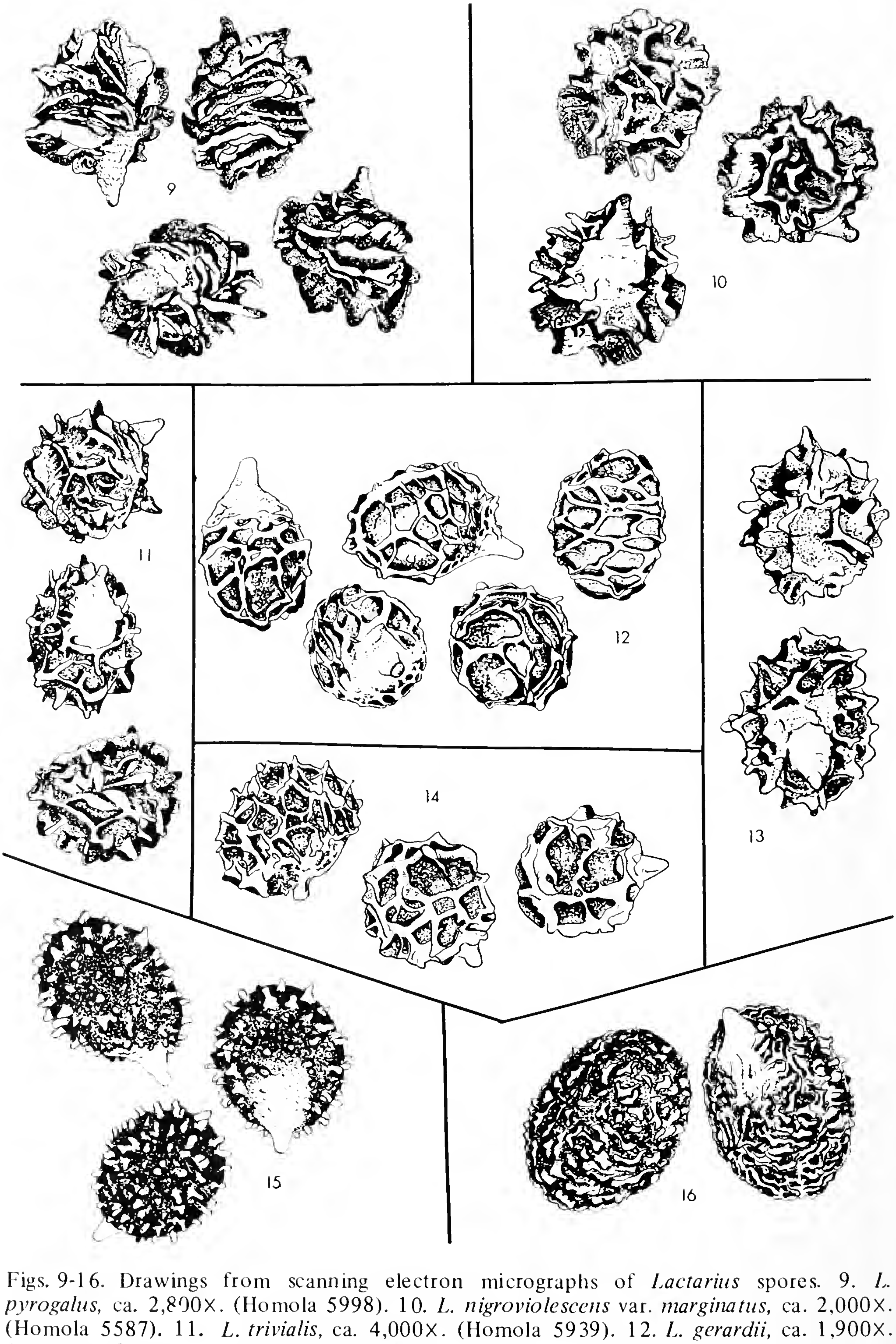

Figs. 9-16. Drawings from scanning electron micrographs of *Lactarius* spores. 9. *L. pyrogalus*, ca. 2,890X. (Homola 5998). 10. *L. nigroviolescens* var. *marginatus*, ca. 2,000X. (Homola 5587). 11. *L. trivialis*, ca. 4,000X. (Homola 5939). 12. *L. gerardii*, ca. 1,900X. (Homola 5937). 13. *L. vinaceorufescens* var. *fallax*, ca. 3,100X. (Homola 5591). 14. *L. volemus*, ca. 1,000X. (Homola 6002). 15. *L. deceptivus*, ca. 2,000X. (Homola 5588). 16. *L. subvellereus* var. *subvellereus*, ca. 3,100X. (Homola 5589).

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Review

GREAT LAKES NATURE GUIDE. Paul A. Herbert. M.U.C.C., Box 2235, Lansing 48911. n.d. [1974?]. 104 pp. $1.00.

It is unfortunate that so much misinformation regarding Michigan plants is herewith disseminated by MUCC, whose name deserves to be associated with more accurate publications. There is little evidence that the work benefitted from the services of knowledgeable editors or proofreaders. (I have not looked carefully at the non-botanical material, but the absurd description of the monarch butterfly caterpillar does not inspire confidence.) Among the principal errors discovered in just 30 minutes' reading are the following: (1) Scientific names of over 20 plants are misspelled (not including the 50-years-obsolete name *Picea canadensis* used for black spruce). (2) Four of the illustrations clearly do not show the plants named beneath (these are not taxonomic splittings—three of the four represent the wrong genus, family, or division of the plant kingdom). (3) At least three species are attributed to Michigan which in fact are not known from the state at all. (4) Gross understatements of the numbers of species in Michigan are made in various groups (e.g., "one" white-flowered violet, when we have in fact 6; "8" pondweeds, when we have at least 30; 10 panic grasses, when we have about 30—or more if one splits). (5) At least 8 species are said to occur "throughout" or "all over" Michigan which in fact have very much more restricted ranges (e.g., *Phytolacca americana, Cuscuta gronovii, Vernonia altissima*). (6) At least 3 species are said to be restricted to one Peninsula (or less) when in fact they do occur throughout the state from the southern border to Isle Royale.

The guide treats over 400 diverse plants and animals, with drawings and concise text. Despite the broad title, the copious notes on distribution pertain only to Michigan. In the preface, MUCC makes the ambitious offer "to confirm the identification of any species here described, or identify any not included." Send them your next batch of *Carex*, crustose lichens, or microlepidoptera!

—E.G.V.

THE VERTICAL ZONATION OF *SPHAGNUM* SPECIES IN HUMMOCK-HOLLOW COMPLEXES IN NORTHERN MICHIGAN

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Sphagnum has basic importance in the ecology of the wetlands of arctic and boreal regions. In addition to its ability to soak up large amounts of water, it can create an acid habitat by exchange of hydrogen ions for other cations in solution, such as Ca^{++}, Mg^{++}, K^{+}, and Na^{+}. It is thus able to make a habitat suitable to itself and other bog plants and to control the direction of bog development.

Many workers have studied the ecology of *Sphagnum* bogs and *Sphagnum*-dominated fens, but not many have included the species of *Sphagnum* and their roles at different stages of succession. Several authors have given some evidence for correlating hydrogen-ion concentration with the ecological niches occupied by the various species of *Sphagnum*. Conway (1949), for example, arranged species in the following order of increasing acidity: *Sphagnum squarrosum, S. subsecundum, S. cuspidatum, S. recurvum, S. magellanicum*, and *S. capillaceum*. The species can also be arranged in a wet-dry successional series, as suggested by Rose (1953), Moss (1953), and Couderc and Le Goff (1970), among others. The first quantitative data on the relationship between *Sphagnum* species and their position above the water level were reported by Lumiala (1944), who noted the vertical distribution of many bog plants and showed, for example, that *S. cuspidatum* is found between 10 cm below the water table and five above, while *S. fuscum* is found between 10 and 40 cm above. Ratcliffe and Walker (1958), working in Scotland, described a sequence of species above water level as *S. cuspidatum–S. papillosum–S. magellanicum–S. rubellum* (*S. capillaceum* var. *tenellum*). They, and also Rose (1953), demonstrated that in Great Britain there is a hummock-hollow complex beginning with *S. cuspidatum* in pools followed by *S. papillosum* or *S. magellanicum* on flat or low hummocks and *S. rubellum* on medium and tall hummocks. Rose also gave evidence of a pH gradient, with lesser acidity in pools than at the top of hummocks.

Our study was undertaken to determine the correlation of *Sphagnum* species to pH and moisture gradients in hummock-hollow complexes. Our observations are limited to open mat communities in northern Michigan, near the Straits of Mackinac. Most European literature on the subject deals with raised, blanket, or valley bogs. The bog mats in our area, originating at the margins of kettle-hole lakes and eventually filling them in, are flat bogs best considered fens dominated by *Sphagnum* rather than true bogs, having developed in contact with mineral-rich ground waters. We have referred to them as bogs only as a convenience based on common parlance. The species of *Sphagnum* which we studied are widespread in the Northern Hemisphere and common in various types of peatland habitats.

Four mature hummock-hollow complexes were selected in each of five bogs located in Emmet, Cheboygan, and Alpena counties: GATES BOG: Cheboygan Co. R3W, T37N, Sect. 22, NW¼; in center and E end of bog. GLEASON'S BOG: Cheboygan Co. R3W, T37N, Sect. 32, NW¼; in E end of bog. KALMIA BOG: Alpena Co. R6E, T31N, Sect. 12; in center and S end of bog. LINSEY MARSH: Cheboygan Co. R1E, T37N, Sect. 21, SE¼NE¼; in open *Sphagnum-Chamaedaphne* mat. STUTSMANVILLE BOG: Emmet Co. R6W, T36N, Sect. 23, SE¼NW¼; in *Chamaedaphne* mat E of bog lake. The study areas were located in communities where the predominant vascular plants were *Chamaedaphne calyculata* and *Vaccinium angustifolium* (Fig. 5). All the study areas were characterized by large hummocks from 30 to 80 cm high (Fig. 6), an almost total absence of trees, and no open water. Criteria used for selection of the 20 complexes were a hummock height of 40-80 cm, at least 95% cover of *Sphagnum*, the presence of at least three species of *Sphagnum*, and the absence of disturbance (such as regeneration stages formed by mats of hepatics and pathways in the depressions). Hummock-hollow complexes which met these four criteria were considered to be topographically mature. (It should be noted that Gates Bog was disturbed by fire in 1918, the east end severely so. Hummocks selected in that area, however, appeared to be undisturbed.)

Each complex was studied as a quadrat two meters square and mapped as to species of *Sphagnum*. The height of each species above water level was recorded. Readings of pH values were made in the field July 19-28, 1971, using a Beckman Electromate pH Meter; readings were recorded in duplicate from several sites for each species of *Sphagnum* by inserting the probe 1-2 cm into the mat.

Water-holding capacity was measured by gathering ten samples of each taxon from localities throughout the Straits region. Each collection, consisting of 20 to 30 living plants, was soaked for a minimum of 15 minutes in tap water at room temperature. Excess water was removed by shaking the sample and allowing it to drip for five minutes. The plants were weighed on a Mettler Balance Model H20 and then dried in an oven at 130° for 18 hours before weighing.

The ability of *Sphagnum* to take up and retain water depends on two processes: The large, empty hyaline cells of leaves, stems, and branches hold water internally, and water of capillarity is held externally owing to the crowding of plants in mats as well as the dense arrangement of leaves and branches. The amount of water absorbed and held varies with the growth habit of the species. Our measurements were not sufficiently standardized to give correct values or really adequate comparisons of the water relations of the species as they exist in nature. We should have weighed equal volumes of plants in their original growth, whether loosely or compactly tufted, and should also have found a better means of wetting specimens, in a saturated atmosphere, for example.

One of the major characteristics of peatland communities is a low pH, usually in the range of 2.7 to 6.5 (rarely 7.4). We have been concerned only with the acidity of the various species of *Sphagnum*, but other factors on which pH values depend, to an extent at least, include the nature of the parent substrate and the groundwater, the presence and abundance of *Sphagnum* in the community, the amount and time of precipitation, distance from open water and the acidity of that water, and also the depth of accumulated peat.

The mean pH values for the five most common species of *Sphagnum* found in the hummock-hollow complexes are listed below. The differences between all means, except that between *Sphagnum fuscum* and *S. capillaceum*, are significantly different at the 0.05 level (t-test). Mean pH values range from 3.99 at the bottom of the hummock or in the hollow to 2.89 at the top of the hummock. The relationship of the means and standard deviations of pH to the vertical profile of a hummock is shown in Figure 1. Figures 2-4 illustrate vertical profiles of three of the hummock-hollow complexes. They show that as the distance above the water level increases, the pH decreases. In general, there seems to be a difference of 1.0 to 1.5 pH units between the top and bottom of large hummocks. The mean decrease ranges from 0.15 to 0.22 pH units per decimeter of height, with the largest decrease occurring near the bases of hummocks.

Hydrogen-ion concentrations may depend in part on availability of water. As one progresses up a hummock, conditions become dryer and more acid, but directly after a hard rain pH values probably increase because of dilution.

Spearing (1972) found a high correlation between galacturonic acid content and the cation-exchange capacity in eight species of *Sphagnum* in New York State and also between cation-exchange capacity and optimum elevation for growth (that is, height above water level). Her cation-exchange capacity data and our pH data give an interesting comparison:

	Mean pH	Cation-exchange capacity
Sphagnum fuscum	2.89	1.000
Sphagnum capillaceum (= *S. nemoreum*)	3.03	0.969
Sphagnum magellanicum	3.16	0.966
Sphagnum recurvum (= *S. fallax*)	3.53	0.829
Sphagnum cuspidatum	3.99	0.799

Thus it seems that species with a high cation-exchange capacity are also those which exhibit a low pH and vice versa. By extrapolation one could conclude that the pH associated with a particular species of *Sphagnum* is related to the amount of galacturonic acid found in that species.

An interesting aspect of cation-exchange capacity, which as far as we know has not been investigated, is the degree of base saturation in *Sphagnum* and whether it is similar in each of the species. If the degree of base saturation is not similar, then the pH will be related not only to the cation-exchange capacity as determined by the amount of galacturonic acid but also by the degree of base saturation of the galacturonic acid.

In bog communities in northern Michigan there are two wet-dry gradients. One traverses the bog from open water to bog forest and consists of several intergrading yet usually distinct communities. The second, which is dealt with here, is from hollow to hummock top. Within this hollow-hummock or vertical gradient there is a definite order of species. This order, illustrated in Figures 2-4, in northern Michigan bogs consists of *S. cuspidatum* (or sometimes *S. majus*)–*S. recurvum*–*S. magellanicum*–*S. capillaceum*–*S. capillaceum* var. *tenellum*–*S. fuscum*.

If the hollows are below the water level, either *S. cuspidatum* (Fig. 7) or *S. majus* (Fig. 8) is present. The factors controlling the distribution of these species is an unsettled matter, but it appears that *S. majus* is more often found in the shallow, minerotrophic moat surrounding most bog mats. *Sphagnum cuspidatum* is usually found in younger parts of the open mat, in shallow pools and sometimes submerged in the lake itself. In *Chamaedaphne*-

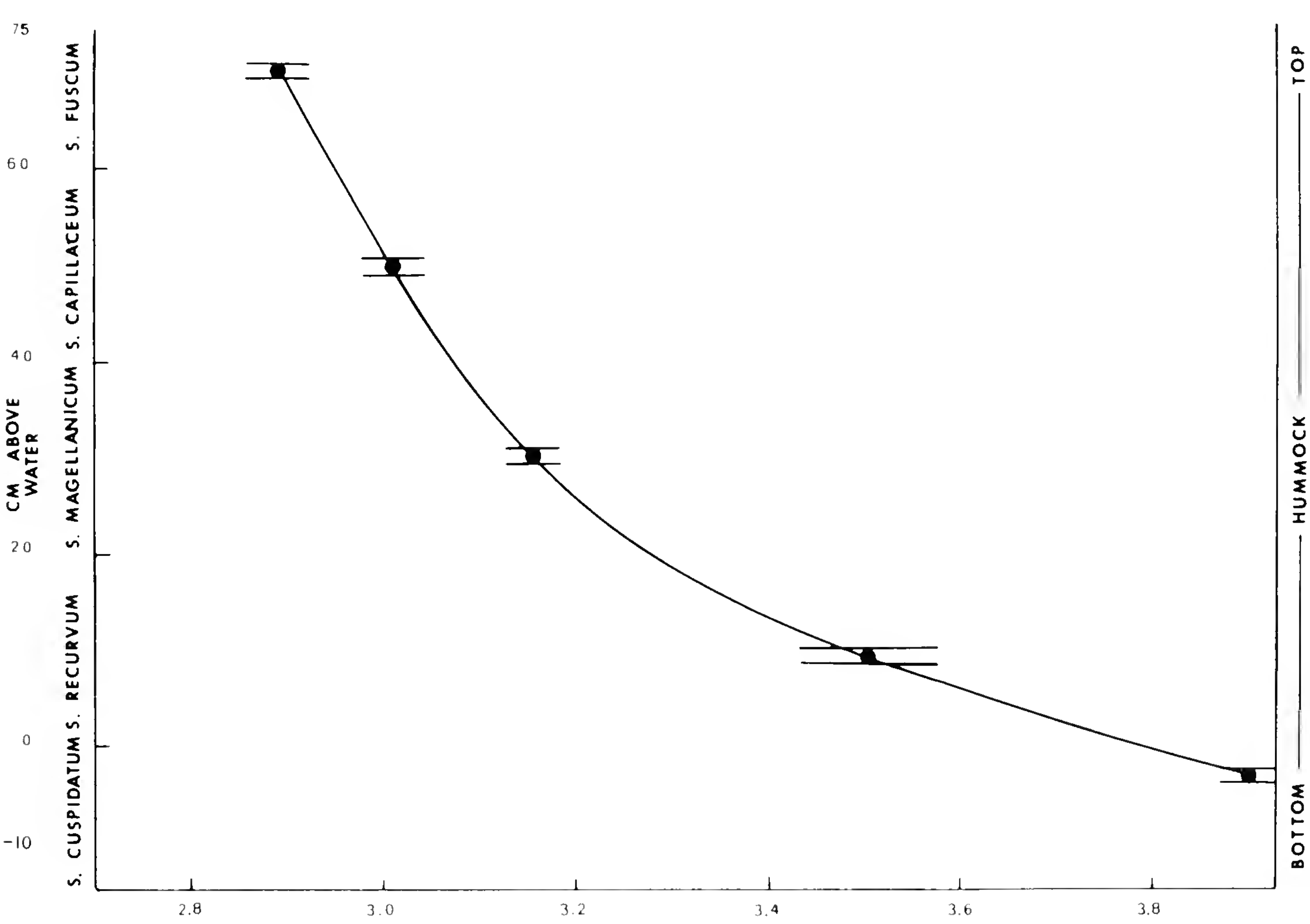
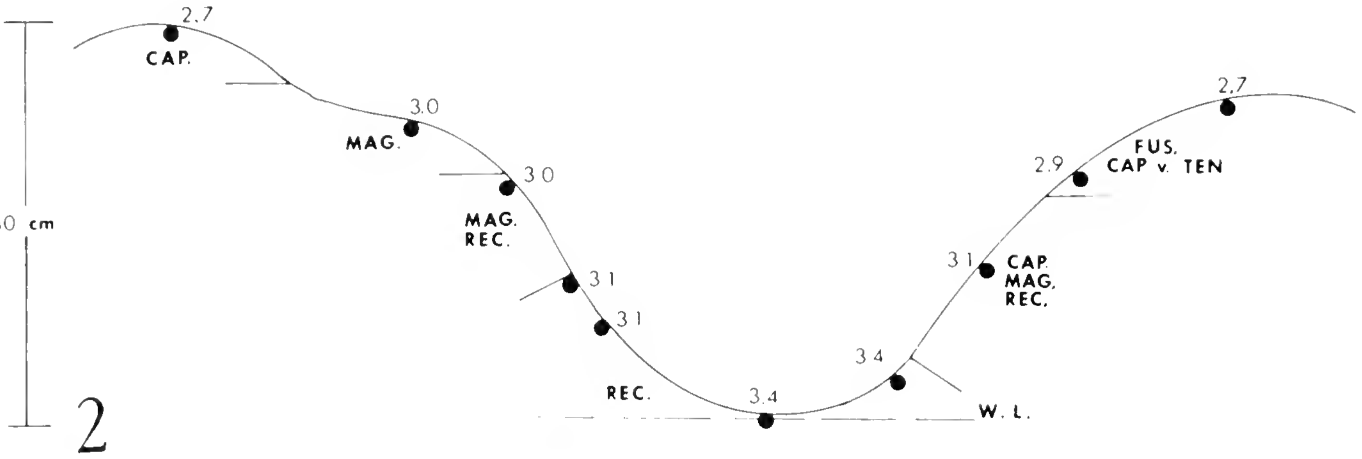
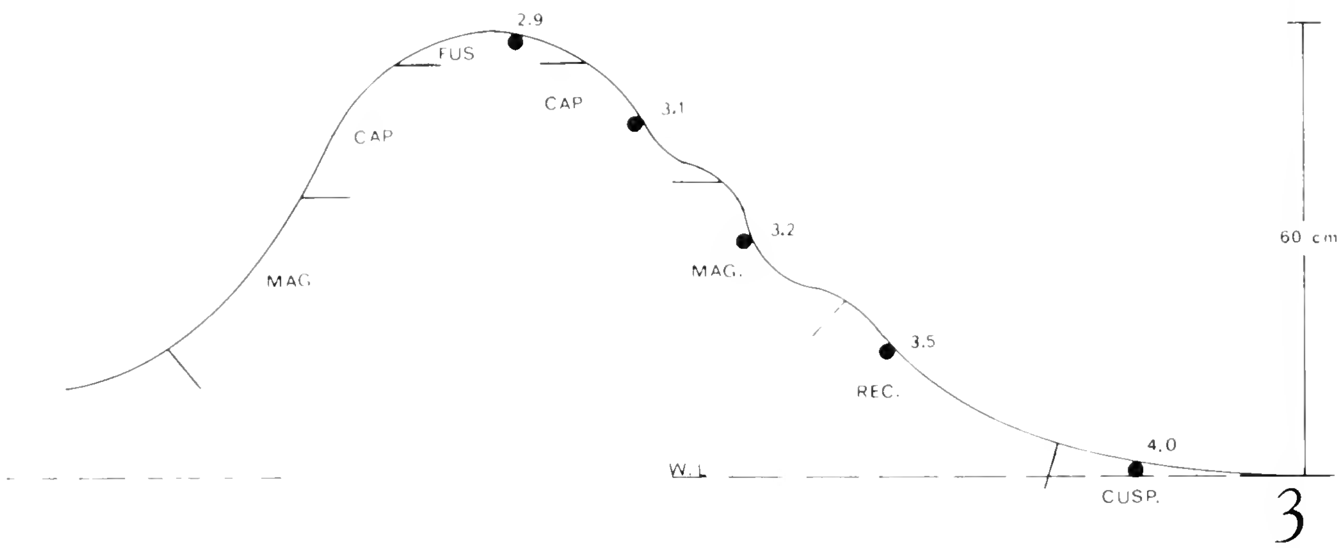


Fig. 1. Relationship of mean pH to vertical distribution of five *Sphagnum* species and to height above water level. Horizontal lines = standard deviation of mean.





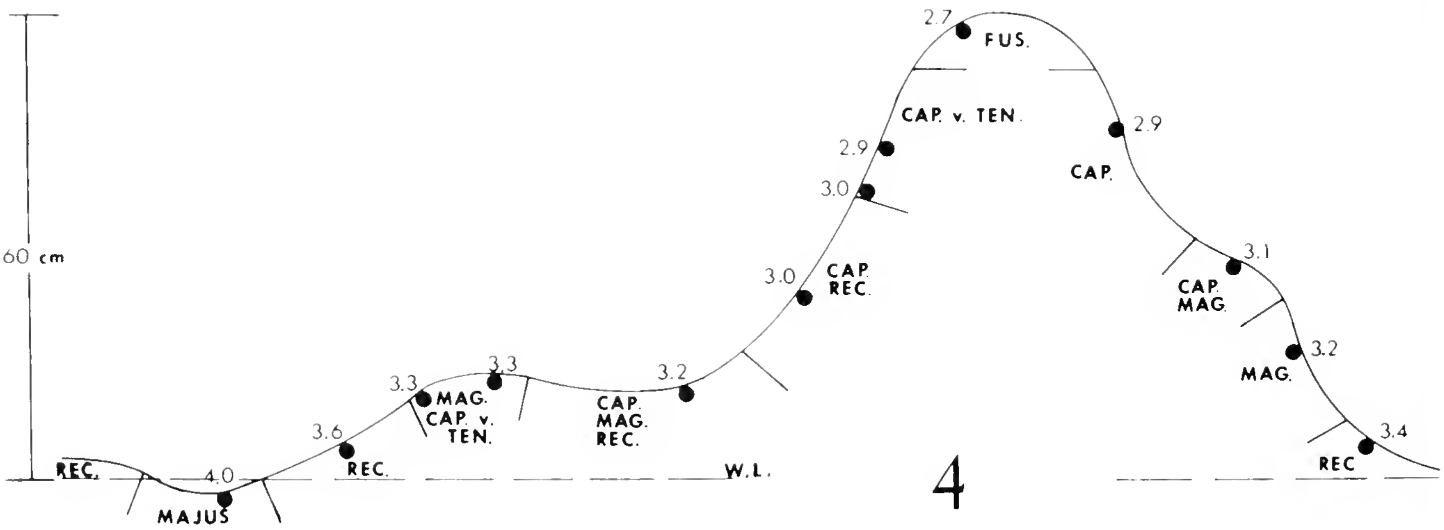


Fig. 2. Hummock-hollow complex from Linsey Marsh. The hollow is above the water level (w.1.) and the hummocks are medium-sized (40 cm high). The numbers are pH readings, and the abbreviations correspond to the first three letters of the species' names discussed in the text. Fig. 3. Hummock-hollow complex from Gates Bog. The hollow is even with the water level, and the hummock is large (60 cm). Fig. 4. Hummock-hollow complex in Linsey Marsh. The hollow is below the water level, the hummock is large, and a second small hummock is developing on the left.

Vaccinium communities *S. cuspidatum* was found in 80% of the submerged hollows, while *S. majus* was present in only 20%. (At Gates Bog, where some of our data were collected, *S. majus* and *S. cuspidatum* occur in the very wet eastern end of the bog which was severely altered by burning; *S. majus* is not normally found in undisturbed bog mats.) At the bases of hummocks or wherever the hollows are above the bog water level, *S. cuspidatum* and *S. majus* are replaced by *S. recurvum*. *Sphagnum recurvum* grows in loose carpets or mounds but not in hummocks. In dryer habitats it is almost always replaced by *S. magellanicum* (Fig. 9). It is able to hold relatively small amounts of water (ca. 15 gm H_2O/gm dry wt.), whereas *S. magellanicum* can hold large amounts (ca. 23 gm H_2O/gm dry wt.). Mixed stands of *S. recurvum* and *S. magellanicum* are frequently observed on small hummocks. In late July or early August, when rainfall is somewhat reduced and the bogs often become fairly dry, *S. magellanicum* may be found in a wetted state with its hyaline cells full of water, while growing intermixed with it *S. recurvum* will be dry. *Sphagnum recurvum* has a lesser ability to retain water under stress. One factor which could enable *S. magellanicum* to grow higher on hummocks than *S. recurvum* may be its ability to absorb more water and retain it longer.

Sphagnum magellanicum is extremely common in open mats where it forms low hummocks. Whenever large hummocks of approximately 60 cm in height are formed, the species is found on the vertical sides of the hummocks, always above *S. recurvum* and below *S. capillaceum* (see Figs. 3-4). Rarely, however, as shown by Fig. 12, *S. magellanicum* forms larger hummocks. In this situation, the top of the hummock often contains the moss *Polytrichum juniperinum* var. *affine*. This situation is most common under shaded conditions. In Great Britain, *S. papillosum* acts in a similar way as a hummock former (Ratcliffe & Walker, 1958). In Michigan, this species grows in low mats in younger, relatively eutrophic portions of bog mats, not in hummock-hollow portions of bogs, and is not an important peat former, as it is in Europe.

Sphagnum capillaceum is found on larger hummocks (Fig. 6), replacing *S. magellanicum* in dryer situations and often crowning the hummock. Figure 11 shows a hummock in which isolated, individual strands of *S. magellanicum* and *S. recurvum* are found as mixtures in an almost solid mat of *S. capillaceum* left over from a smaller hummock in which *S. magellanicum* and *S. recurvum* had been dominants. In many cases, particularly in bogs of well-developed hummocks about 60-80 cm high, *S. capillaceum* is replaced by *S. capillaceum* var. *tenellum* and, under the dryest conditions, by *S. fuscum*. However, all three of the latter can be found at the top of large hummocks. Further drying of large hummocks results in the replacement of *S. fuscum* or *S. capillaceum* by *Polytrichum juniperinum* var. *affine* and *Aulacomnium palustre*.

In view of a distinct wet-to-dry gradient from bottom to top of hummocks, it was expected that the water-holding capacity of the species would follow the same sequence. However, this is not the case, as shown by the following values arranged in order of wet-to-dry niche relationships. The

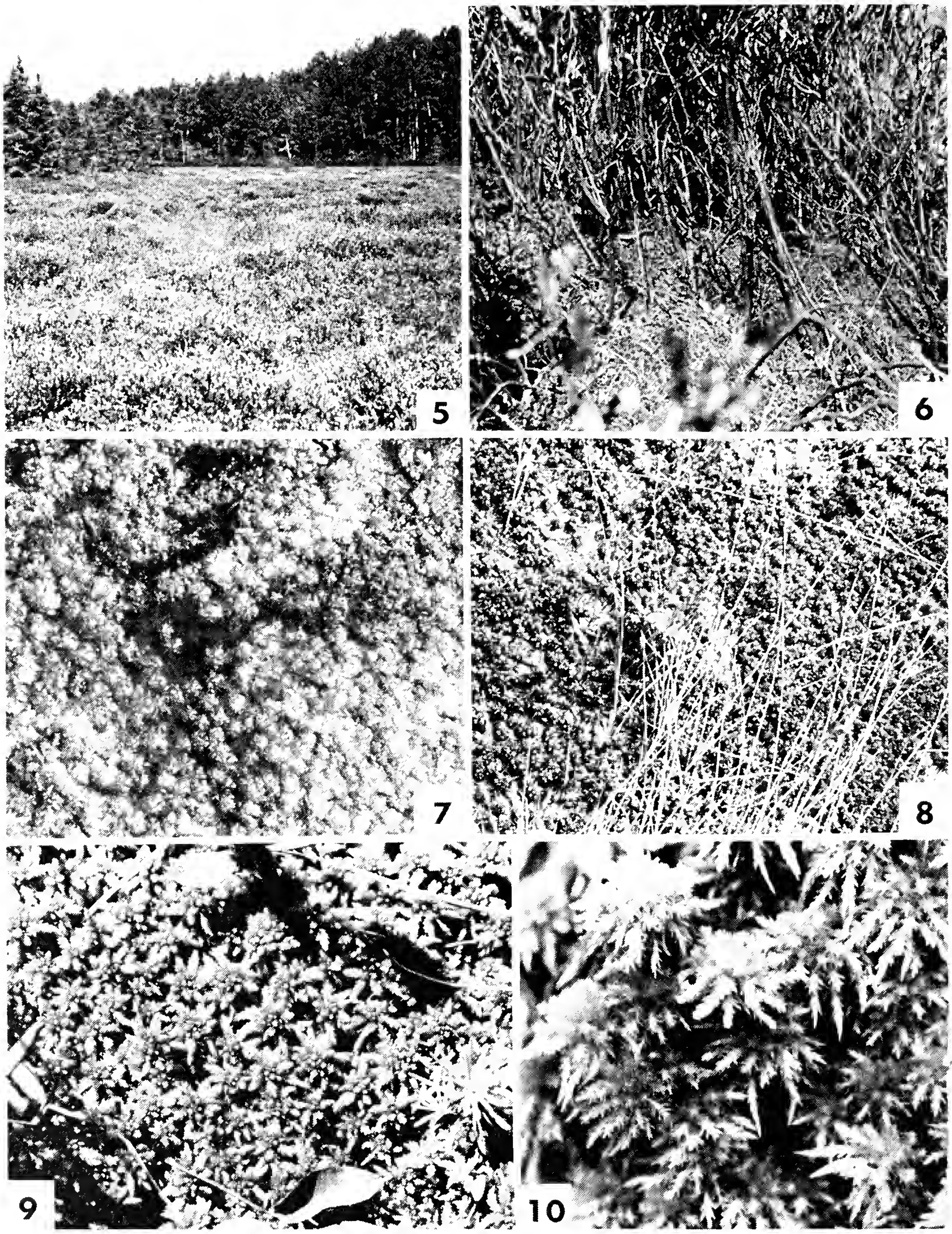


Fig. 5. An expanse of open bog at Mud Lake, Inverness Tp., Cheboygan Co., typical of the habitat in which this study was completed. The major vascular plants are *Chamaedaphne calyculata* and several *Vaccinium* species, the most common of which is *Vaccinium angustifolium*. The shrub border zone in the background consists of *Nemopanthus mucronata* and *Ilex verticillata* as dominants. Hummocks are approximately 50-70 cm high, and the hollows are mostly above water level. Fig. 6. A hummock of *S. capillaceum* in a relatively dry *Chamaedaphne calyculata* community. Fig. 7. *Sphagnum cuspidatum* showing its submerged habitat. Fig. 8. *Sphagnum majus* in its submerged habitat in the moat zone. Fig. 9. *Sphagnum magellanicum*. Fig. 10. *Sphagnum compactum*.

values are computed from a ratio of grams of water absorbed to the dry weight of plants (followed in each case by the standard error).

S. cuspidatum	20.43	(.80)
S. majus	17.23	(.70)
S. recurvum	14.90	(.38)
S. magellanicum	23.17	(.62)
S. capillaceum var. *tenellum*	15.94	(.79)
S. fuscum	16.97	(.43)

As explained above, the methods were not well chosen. More meaningful values would have taken into account the actual habit of growth and its effect on water movement, absorption, and retention. They do indicate, however, that all the species, regardless of their ecological role, hold a significant amount of water (about 15-23 times their dry weights).

Hummock formation can take place in two ways: A species of *Sphagnum*—most often *S. capillaceum*—can initiate a hummock by growing on and among lower branches of shrubs such as *Chamaedaphne* and larger species of *Vaccinium* (Fig. 6). As the hummock of *S. capillaceum* becomes larger, *S. magellanicum* and *S. recurvum* replace *S. capillaceum* on shaded, moister sides. Further vertical growth leads to replacement of the upper portions of *S. capillaceum* by *S. fuscum*, which forms the cap of the hummock in mature situations. A second means of hummock formation occurs when *S. recurvum* growing in low mats in wet situations is replaced by *S. magellanicum* which may form hummocks up to 40 cm high. As conditions become dryer and more acid, *S. magellanicum* is in turn replaced by *S. capillaceum* and finally by *S. fuscum*. (In this latter situation individual strands of *S. magellanicum* and *S. recurvum* are often found among the *S. capillaceum*.)

The six taxa of *Sphagnum* discussed above are major components of the hummock-hollow complex in *Chamaedaphne-Vaccinium* communities. Three other taxa occasional in this habitat did not occur in our study plots. *Sphagnum capillaceum* var. *tenerum* is sometimes found with *S. capillaceum* var. *capillaceum* and *S. fuscum* but so sporadically that little is known about its habitat preferences. *Sphagnum fimbriatum* often forms loose mounds of medium size, particularly in open areas near the older, outer margin of the bog, often in areas of dense *Chamaedaphne*. It is rarely, if ever, associated with the hummock-hollow complex as described here but forms pure mounds supported by lower branches of *Chamaedaphne*. *Sphagnum russowii* occasionally grows in *Chamaedaphne-Vaccinium* zones but usually where there are high shrubs or trees near the periphery of the open mat. It is also common in dryer portions of moats. When it occurs in the hummock-hollow complex it forms low, pure hummocks usually just above the *S. recurvum* zone and sometimes continuing as high as the *S. magellanicum* zone. Occasionally, isolated strands of *S. russowii* are intermixed in lower portions of the *S. capillaceum* region. *Sphagnum russowii* occurs in a variety of habitats and is, in fact, one of the most sociable of all our species, but it is not important in the hummock-hollow complex dealt with here. *Sphagnum compactum* (Fig.

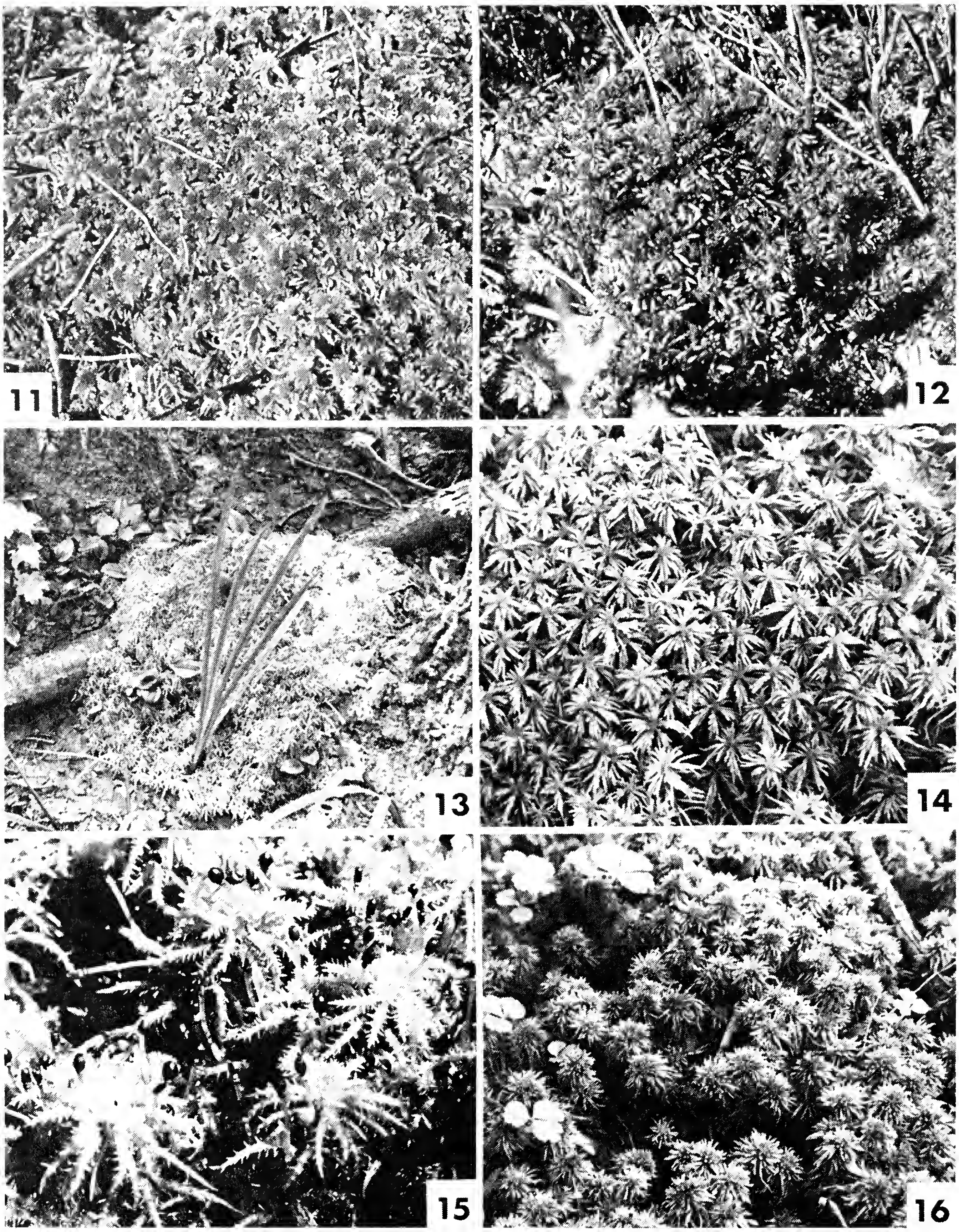


Fig. 11. A 50 cm hummock composed of *Sphagnum capillaceum*, with remnants of *S. recurvum* (arrow at right) and *S. magellanicum* (arrows on left). Fig. 12. A 30 cm hummock composed of *S. magellanicum* with some *Polytrichum juniperinum* var. *affine* (arrow). Fig. 13. *Sphagnum girgensohnii* forming a loose mound in a *Thuja* swamp. The mound is situated on leaf litter; the absence of standing water is notable. Fig. 14. A close-up of *Sphagnum girgensohnii*. Fig. 15. *Sphagnum squarrosum*. Fig. 16. *Sphagnum wulfianum*.

10) forms small cushions at the edge of Gates Bog in places where dry aspen-covered slopes join the open mat with no intervening moat. The species is rare in northern Michigan where it is associated with seepage at the sandy margins of bogs. It does not take part in hummock formation.

Hummock development in open *Chamaedaphne-Vaccinium* communities involves a number of species, each occupying a particular zone in the vertical gradient. In shaded, woodland habitats, such as *Thuja occidentalis* swamps and *Picea mariana* bog forests, are other species of *Sphagnum*. *Sphagnum wulfianum* (Fig. 16) occurs on ridges corresponding to logs in an advanced state of decomposition. *Sphagnum girgensohnii* (Figs. 13, 14) forms loose, low but often extensive mounds up to 30 cm high. *Sphagnum centrale* grows in very compact hummocks, similar in height but less extensive. *Sphagnum squarrosum* (Fig. 15) occurs in loose mats, in depressions never in hummocks. The woodland *Sphagna* generally grow in pure colonies, not in the mosaic of species characterizing hummock-hollow complexes in open mat communities.

Disturbance to hummocks is common in northern Michigan. Many of the bogs have been repeatedly burned and are presently frequented by cattle or humans, the latter usually harvesting blueberries. Disturbance often leads to erosion of the sides (but not the tops) of the hummocks which are then colonized by several species of hepatics, such as *Cephalozia pleniceps, Calypogeia sphagnicola, Cladopodiella fluitans, Mylia anomala,* and *Microlepidozia setacea.* The local history of hummock formation is complicated by periodic drought, sawfly epidemics (influencing the growth of tamaracks), fires, drainage, and other disturbances. We have little direct evidence of layered succession, but we did examine the interior of several large hummocks. In one case, in Gates Bog, a hummock of *S. magellanicum* was underlain by decayed remains of *S. recurvum* and *S. cuspidatum,* clearly indicative of a hollow-to-hummock change. But, on the other hand, in four hummocks capped by *S. capillaceum,* the same species was found downward as far as decay permitted identification.

We have seen no local evidence of cyclic succession. Numerous European authors have reported that as hummocks mature, they may be colonized by mosses, lichens, shrubs, or even trees. Owing to subsequent shading, *Sphagnum* growth is inhibited and decomposition sets in, with the result that the hummock becomes a hollow at the same time that surrounding hollows become hummocks through successive stages such as those described above. A continuous regeneration cycle appears to be a feature of true bogs in areas of high humidity but not the flat bogs or poor fens of our continental interior where *Sphagnum* growth and peat accumulation are minimal. (From our observations in Michigan, we are inclined to doubt the evidence of cyclic succession in Alberta as reported by Moss, 1953.) It is true that in the bogs of northern Michigan, groups of tamarack and black spruce invariably center around holes where *Sphagnum* once grew, but such island-like clumps of trees seem to be self-perpetuating and not subject to cyclic disappearance and regeneration.

SUMMARY

The vertical sequence of species in hummock-hollow complexes investigated in northern Michigan begins with *Sphagnum cuspidatum* (and, atypically, *S. majus*) submerged in hollows. *Sphagnum recurvum* occurs at bases and lower sides of hummocks, while *Sphagnum magellanicum* is found on the sides, particularly on steeper faces above *S. recurvum*. *Sphagnum capillaceum* occurs on the upper sides and, on smaller hummocks, covers the top. On larger hummocks, *S. capillaceum* var. *tenellum* replaces the var. *capillaceum*, and the highest hummocks are crowned with *S. fuscum*. This sequence can be viewed as successional. A pH gradient exists between the hollow and the top of the hummock with a significant decrease in pH values as height above the water table increases. It is suggested that pH is dependent at least in part on the galacturonic acid content and cation-exchange capacity of individual species of *Sphagnum* and in part on amounts of water present in the system. The sequence is also related to a water gradient.

ACKNOWLEDGMENTS

This research was supported by the National Research Council of Canada grant A-6390 to the senior author. Field work was done at the University of Michigan Biological Station, Pellston, Michigan, during the summers of 1970 and 1971. We are indebted for the 1970 field work to funds from a University of Michigan Faculty Research Grant NSF GU3470 Project 149 to the second author. We are grateful to Dr. Nancy Slack for numerous suggestions and considerable help in carrying out this research.

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A BUNCHBERRY "LAST ROSE OF SUMMER"

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No enumeration of showy wildflowers of the Great Lakes area is complete without the Bunchberry or Dwarf Cornel, *Cornus canadensis* L. In many respects, technically, it is a dwarf Flowering Dogwood, *C. florida* L. It has clusters of small greenish-white flowers surrounded by four large white bracts as in the Flowering Dogwood; the fruits are in tight clusters and they are large and bright red. Normally Bunchberry flowers in June and July and bears its mature fruits in August and September.

During a recent field trip to the Upper Peninsula of Michigan in search of rare clubmosses, Florence S. Wagner, Joseph Beitel, and I noticed thousands of plants of Bunchberry in various localities. On 22 September 1974 most of the plants had dropped many or all of their fruits, and the active season of growth and reproduction of this plant was obviously nearing an end. At one locality on the north side of route 28 in Chippewa County we found low sandy hills practically covered with Bunchberry colonies. To our great surprise one of the plants appeared to bear a *white rose*! As we neared it, we realized that it was actually in bloom this late in the season. However, the arrangement of the flowers was most remarkable: instead of a single group of flowers surrounded by four white bracts, there were actually four distinct clusters of flowers of peculiar form.

Most popular garden roses are said to be "doubled," i.e., there is duplication of petals. Instead of only 5 petals, as found in wild-type roses, a varying number of other floral organs, the stamens, have become converted into petals. These petals, except for the outermost ones, are often reduced in size and variously abortive. In our Bunchberry specimen we are dealing with a very different and yet in some ways similar phenomenon. As shown in the figure, there has been duplication of the "petals," but these are actually false petals, modified bud scales or bracts. It is especially interesting that in each of the four inflorescences, it is the outermost ones of the petaloid bracts that are largest and most like the normal bracts. Those of the inner sides of the inflorescences are variously reduced in size or abortive, thus again resembling a doubled rose. Once again, however, there is a very profound difference: it is not a single flower, as in a rose, which has been amplified, but a whole inflorescence, made up of many flowers. In this case, a single inflorescence has been amplified into four.

What caused this peculiar "Last Rose of Summer"? The fact that it was the only flowering specimen of *Cornus canadensis* among thousands, and the fact that the time of flowering was two or three months late, indicate that highly abnormal conditions must have prevailed to induce the plant to flower. Since it was a single branch among many from a single clone, it seems likely that we are dealing here with the results of some injury which promoted the bud into renewed but peculiar growth. M. L. Fernald once wrote in connection with Bunchberry that "innumerable minor forms have been noted." Taxonomically speaking the peculiar specimen described here is surely a "minor form." But at the same time, it shows characteristics that mark it morphologically as a very interesting form.

Fig. 1. Doubled Bunchberry inflorescence from Chippewa County, Michigan.

Review

WILD PLANTS IN FLOWER III: DECIDUOUS FOREST. By Torkel Korling; essay and species notes by Robert O. Petty. [Published by the author, Box 92] Dundee, Illinois 60118. 1974. 96 pp. $4.95.

Already we welcome another in what has become an annual "habitat series" displaying the superb color photography of Torkel Korling, in this instance a bumper crop of 44 scenes from one of the best known habitats in eastern North America. The text is rich with historical lore, notes on pollination and other "strategies," and appreciation of natural ecosystems. Be sure to add this volume to your collection (and gift supply)—even though quibblers can always question some points (e.g., inconsistent gender of *Panax; Claytonia caroliniana* compared as "small" and "eastern" rather than broad-leaved and northern; *Astilbe* misidentified as *Aruncus*).

—E.G.V.

VEGETATION AND GEOLOGY OF NORTH FOX ISLAND, LAKE MICHIGAN

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INTRODUCTION

The Fox Islands are part of Leelanau County, Michigan, and consist of two entities: North Fox Island (in T35N, R13W), and South Fox Island (in T34N & T35N, R13W). They are located in Lake Michigan about 20 miles northwest of mainland Leelanau County. The map (Fig. 1) shows that the islands, which are separated by about four miles, are oriented with their longest dimension in a NW to SE direction. North Fox Island (839 acres) is slightly over two miles long in its longest dimension by about one mile wide at its widest point.[1] South Fox Island (3,217 acres) is slightly over five miles long in its longest dimension by about one and one-half miles wide. This report is based upon visits by the three authors (via airplane) to North and South Fox Islands during August, 1973, and another visit, accompanied by Mr. Joseph W. Moore of Charlevoix, to North Fox Island in June, 1974.

An earlier report on these islands was made by Hatt et al. (1948) who discussed 1937 field work which included observations on geology, biota, and record of human habitation on these islands. We know of no published record of human habitation on North Fox Island although in recent years the remains of two cabins were discovered at opposite ends of the island as well as a driven water well casing near the east shore. Hatt et al. (1948) noted that the first record of occupants on South Fox Island was 1846. Further, it was pointed out that by 1926 there were six farms on South Fox Island; the largest was 140 acres and belonged to John Oliver Plank. Other human activities on South Fox included the operation of a lumber camp 1900-1926 and shingle mill (Hatt, 1948). Four graves, presumably Indian, are on South Fox Island. These Indians reportedly worked for the Oval Disk Bowl Company and died during an epidemic of influenza in 1919. During the 1950s and early 1960s the island was again lumbered, by Sterling Nickerson and his sons of Kingsley, Michigan.

Although our records of Fox Islands vegetation are based upon sight records only, herbarium vouchers at the University of Michigan Biological Station include collections from South Fox by E. U. Clover in 1961 and 1962, and by Larry Wolf in 1961. In 1963, Fred Test made several collections from North Fox Island while other of his specimens came from South Fox. Voss (1972) maps over 40 gymnosperms and monocots from the Fox Islands.

[1]Acreages stated for the islands are based on plat book data used for tax purposes.

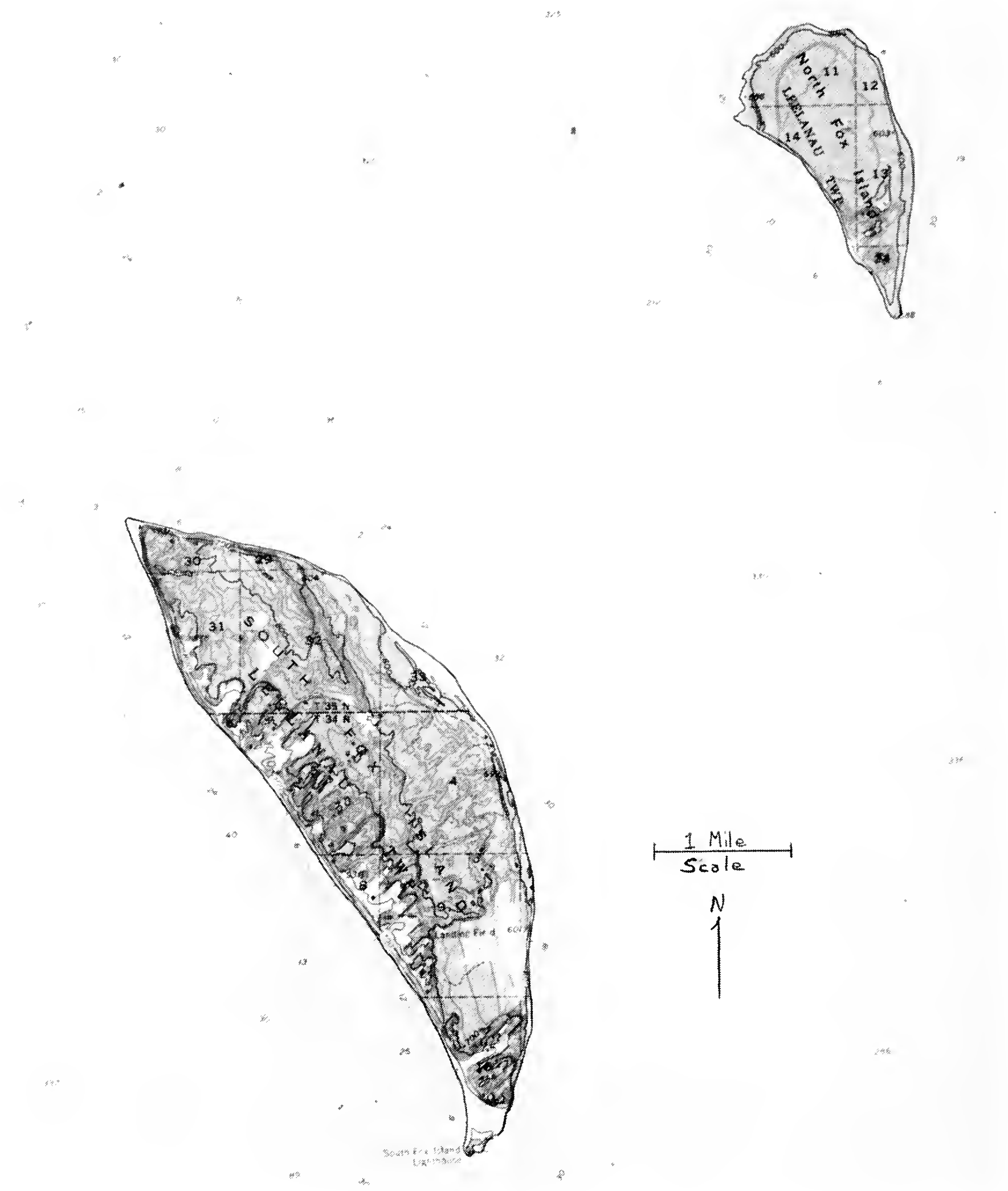

Fig. 1. Map of North and South Fox Islands, Leelanau County, Michigan (U.S. Geological Survey, 1956)

TOPOGRAPHY

Topographically, the central portion of the northern half of North Fox Island consists of a raised plateau of glacial till sloping gently southeast from an elevation above sea level of around 645 feet in the north to about 630 feet at its southern end. The northern border of the plateau is marked by well-defined, steep bluffs about 20 feet high which rise from the basal

Nipissing shoreline elevation of 615 feet. (The elevation of Lake Michigan is 579 feet above sea level.) This northern sector is bordered by broad, gently sloping flats extending approximately 1,000 feet outward from the base of the plateau to the shoreline. South of the west end of the airfield the plateau is terminated by the actively eroding bluff 50 or more feet in height above Lake Michigan, below which lies a narrow, sandy beach. The eastern edge of the plateau is defined by a gently sloping bank flanked by some ancient gravel bars and bordered by a broad lowland strip approximately 700 feet in width. At its south edge the plateau gently descends to about 600 feet above sea level.

The southern half of the island consists principally of a long, narrow triangular plain 600-625 feet in elevation upon which forested sand dunes rise to elevations of over 720 feet. In the center of this dune sector is located a long blowout extending far into the island's largest longitudinal dune, which in turn spreads almost across the whole width of the island in an east-northeast, west-southwest direction (Fig. 2). The long, open sandy trough of the blowout extends from a broad, sandy terrace along the western shore (Fig. 7) to a summit elevation of 725 feet. Its outer slopes are wooded. Directly west of this area is a long underwater boulder ridge which extends out into the lake for some distance (Fig. 3). It was on this reef that the four-masted schooner *Sunnyside* foundered carrying ore in 1883.

Adjacent wooded dunes north of the blowout rise to peaks of 707 and 709 feet from a base of around 615 feet. Wooded dune peaks south of the blowout average 720 feet.

Certain topographic features on South Fox are more extreme than on North Fox. For example, dunes and blowouts along the western shore are more extensive. The highest dunes (in excess of 1,000 feet above sea level and rising over 300 feet above a small plain of glacial till) are found about two miles north of the lighthouse located at the southern tip of the island. Stanley noted (in Hatt, 1948): "The great cliffs [along the west shore] are eloquent of the erosion that has taken place and the soundings on the lake chart indicate that the island has been eaten away almost a mile in places, perhaps much more." He further noted that much of the eroded sand and gravel from the western and northern sectors of South Fox have been deposited along the island's eastern shore.

GEOLOGY

North and South Fox Islands, like the Manitou Islands to the south, appear to be composed entirely of the products of Wisconsin glaciation, strongly modified by the shoreline processes of the post-Chippewa great lakes. During the last retreat of the ice (around 10,500 years ago) pro-glacial Lake Algonquin filled the Lake Michigan basin in front of the wasting ice edge and, when the area of the Fox Islands was at last ice-free, covered both islands entirely. Their surfaces, then rather smooth till plains, received a minor amount of lake sediment and, in all likelihood, a few ice-rafted boulders as well.

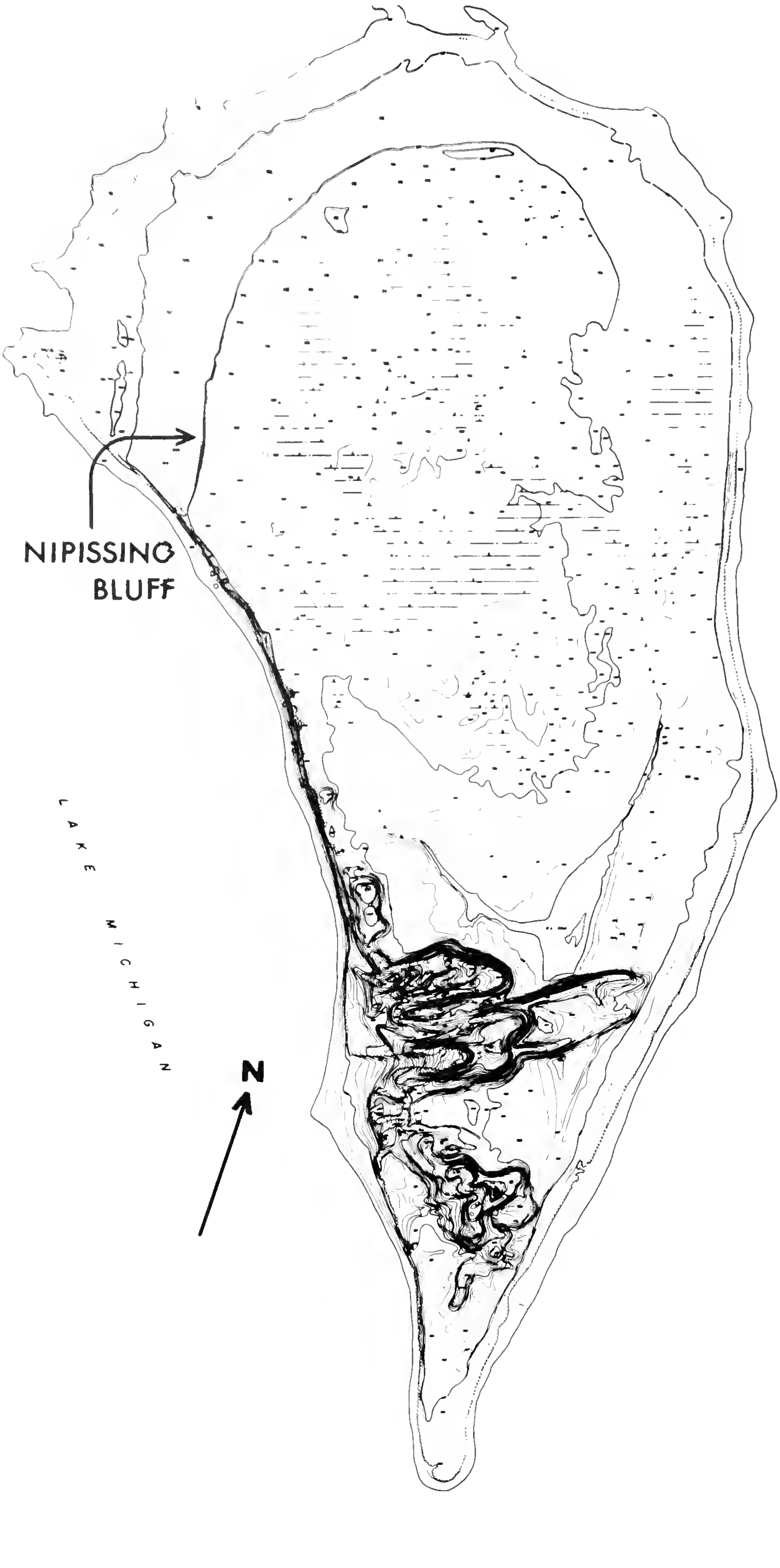

Fig. 2. Map of North Fox Island showing location and extent of dunes and blowout in southern sector.

Around 9,500 years ago, the retreating ice uncovered in the Georgian Bay region lower outlets for the ponded water, and lake levels in the Lake Michigan basin fell rapidly to about 320 feet above sea level. During this time the Fox Islands probably still existed as islands but were much closer to the mainland since lower lake levels uncovered much land presently under water.

With post-glacial uplift of the Georgian Bay region, waters again rose in the Lake Michigan area, reaching a maximum some 4,000 years ago in the Lake Nipissing stage. Since then, levels, with minor reversals, have been falling as the Port Huron outlet has been lowered through basal erosion.

The oldest shoreline features on North Fox Island are at an elevation of 615 feet and are of Nipissing age. At this time the island rose only some 35 feet above the waters and was about half its present size. Strong wave action cut the prominent northern bluff that marks the north shore of the old Nipissing Island. Rock material eroded from here was swept down the east and west shores and deposited at the south end of the island in a series of gravel bars enclosing a triangular lagoon (shown by horizontal lines in Fig. 3). Today this old lagoon is occupied by a seasonal pond.

As the waters fell away from the Nipissing maximum, the island grew larger and a dune complex spread from the western shore across the southern

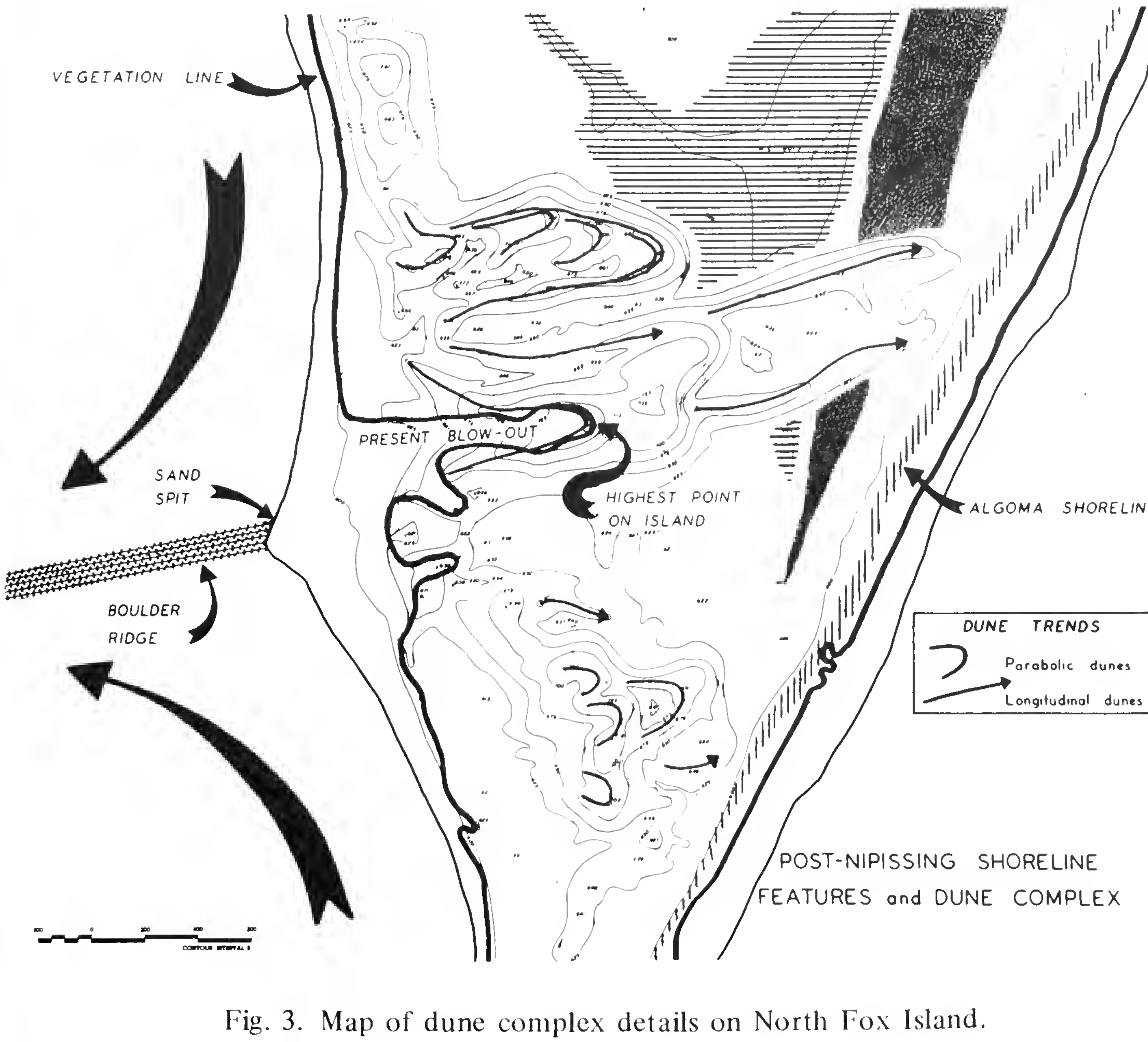

Fig. 3. Map of dune complex details on North Fox Island.

half of the island, burying parts of the old Nipissing gravel bars and lagoon (Fig. 3). Parabolic dunes of deflation predominate; that is, long, scoop-shaped hollows of parabolas of sand, points tapering to windward, with leeward slopes steeper than windward slopes. In the middle of the complex are a few large longitudinal dunes. In the center of this dune sector is located the largest dune on the island which extends as a long blowout almost the entire width of the island in a southwest-northeast direction. Its maximum height is some 155 feet above Lake Michigan. Since parabolic and longitudinal dune axes are thought to be sensitive indicators of prevailing wind-energy directions during time of migration, a west-southwest wind-energy direction can be proposed for this area during this period.

About 3,200 years ago the lake level briefly stabilized in the Fox Islands area at about 605 feet above sea level. During this Algoma stage the lake built some gravel bars on the northwest tip of the island (Fig. 2) and truncated the post-Nipissing dune complex on the east (Fig. 3). A small but pronounced Algoma bluff runs along the whole eastern shore of North Fox Island, just back from the gravel beach (Fig. 4). The remnant of an Algoma shingle beach can be seen partially buried in sand just south of the western end of the blowout. Since the Algoma stage the lake level has continued to drop.

Shoreline erosion, transportation, and deposition continue to this day. Sand continues to move up the one active blowout. An inspection of Fig. 2 shows that the 4,000-year-old Nipissing bluff has been interrupted and cut off at its west end by the presently eroding windward bluff. The same has

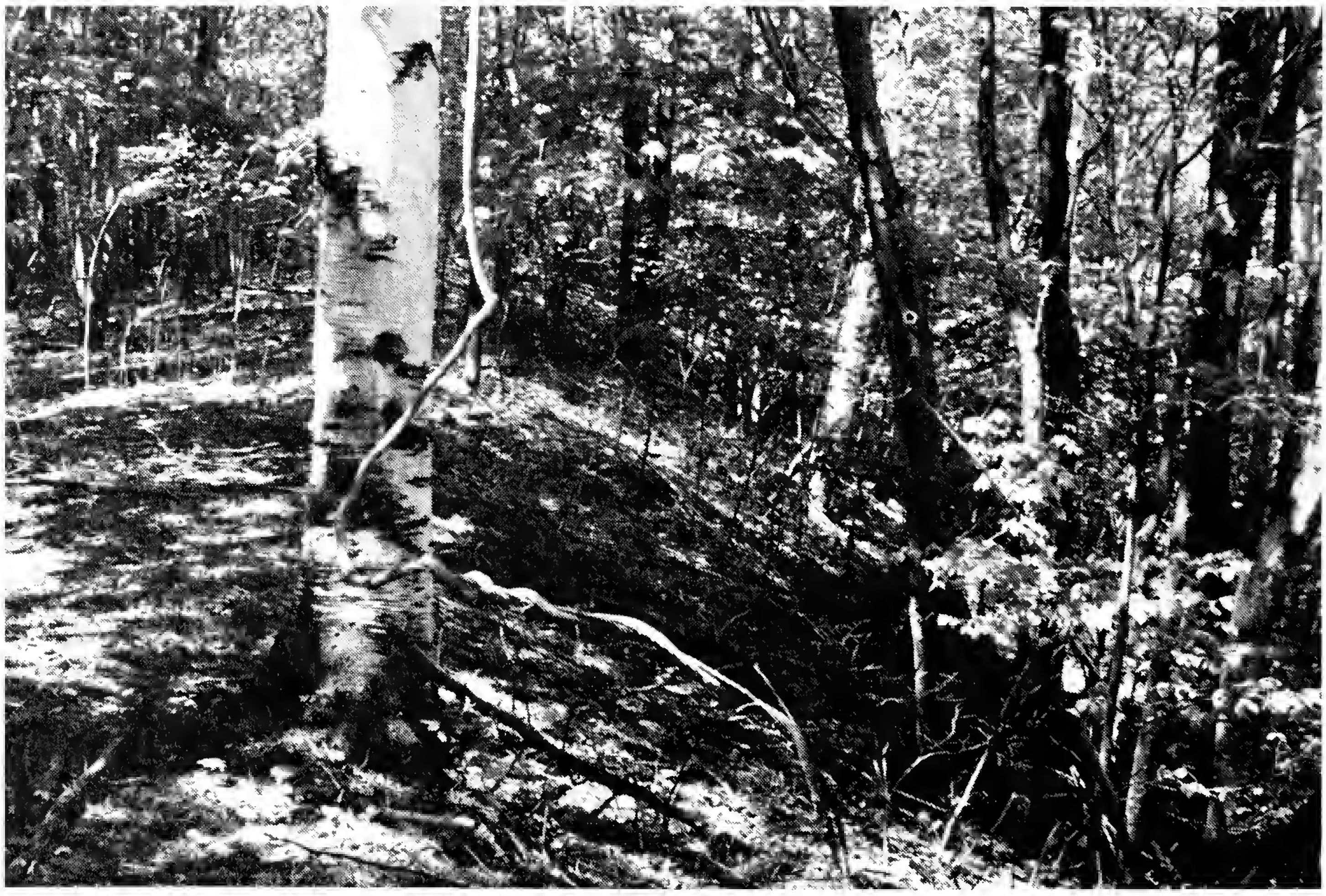

Fig. 4. Lake Nipissing beach along eastern edge of North Fox Island.

happened to the Algoma bar complex at the northwest end of the island. Extrapolating these features out into the lake and calculating erosion rates necessary to account for this much loss of land, a rate of bluff retreat in the order of 5 or 6 inches per year is suggested since Nipissing time.

One interesting recent feature of the western shore is the underwater boulder ridge jutting westward from the blowout dune complex. Stanley (in Hatt, 1948) suggests that this marks the meeting point of opposing shore currents. Movements of winter ice, which in shallow waters is capable of plucking and transporting boulders, may also have played a part in building such a lineal feature.

CLIMATE

No set of weather data specifically relating to these islands is known to exist. The closest U.S. Weather Bureau station is several miles to the east, at Charlevoix, and temperatures there are influenced to a lesser degree by the moderating effects of Lake Michigan than would be expected at the Fox Islands.

A summary of climate in the Grand Traverse Bay area (Brunschweiler & Vogel, 1964) affords some opportunity for extrapolation of Fox Island temperature extremes based on their estimates from a single year—1962. The mean January temperature was close to 21°F while the lowest February temperature was near -5°F. The lowest May temperature was estimated at 32° in the region of the Fox Islands. This would be about 2° warmer than on the shore of the nearest mainland areas some 15 miles eastward. The highest temperatures for May and July would be 82° and 84°, respectively, and this would represent temperatures at least 2° cooler than found on the mainland shores. Even greater differences were noted on the mainland as one moves inland.

HARDWOOD FOREST

A beech-maple forest covers most of the triangular island plateau as well as lower slopes of forested dunes (Figs. 5, 6). Some low areas are occupied by swamp forest vegetation. The dominant hardwoods are sugar maple (*Acer saccharum*) and beech (*Fagus grandifolia*) with admixtures of yellow birch (*Betula alleghaniensis*), basswood (*Tilia americana*), white ash (*Fraxinus americana*), and hop hornbeam (*Ostrya virginiana*). Mountain maple (*Acer spicatum*) is a common understory species and in some areas Canada yew (*Taxus canadensis*) forms an extensive ground cover. Red-berried elder (*Sambucus pubens*) and wild gooseberry (*Ribes cynosbati*) are associated shrubs. No hemlock (*Tsuga canadensis*), striped maple (*Acer pensylvanicum*), or black cherry (*Prunus serotina*) were observed.

During the spring season an extensive ground cover of wild-flowers is evident. Particularly common are dutchman's breeches (*Dicentra cucullaria*), wild garlic (*Allium tricoccum*), and Canada violet (*Viola canadensis*). Other common species are large white trillium (*Trillium grandiflorum*), smooth yellow violet (*Viola eriocarpa*), sweet cicely (*Osmorhiza* sp.), small-flowered

Fig. 5. Beech-maple forest aspect on North Fox Island showing predominance of beech.

crowfoot (*Ranunculus abortivus*), blue cohosh (*Caulophyllum thalictroides*), jack-in-the-pulpit (*Arisaema triphyllum*), early bedstraw (*Galium aparine*), and yellow trout-lily (*Erythronium americanum*). Other associated species include spring beauty (*Claytonia caroliniana*), broadleaved toothwort (*Dentaria diphylla*), cut-leaved toothwort (*D. laciniata*), sharplobed hepatica (*Hepatica acutiloba*), twisted stalk (*Streptopus roseus*), Solomon's seal (*Polygonatum pubescens*), wild sarsaparilla (*Aralia nudicaulis*), early meadow-rue (*Thalictrum dioicum*), and white and red baneberry (*Actaea alba* and *A. rubra*). Ferns found in this habitat are marginal shield-fern (*Dryopteris marginalis*), wood fern (*D. intermedia*), and maidenhair (*Adiantum pedatum*). Other ground cover species include running-pine (*Lycopodium clavatum*) and bristly club-moss (*L. annotinum*).

LOWLAND CONIFER FOREST

The lowland flats surrounding the northern portion of the plateau are dominated by a forest with conifers among the dominants. In other low

Fig. 6. Beech-maple forest on North Fox Island showing predominance of sugar maple and understory of smaller maple trees.

situations just behind the beach area, a similar forest border is often found. Principal trees include balsam fir (*Abies balsamea*), white-cedar (*Thuja occidentalis*), and white birch (*Betula papyrifera*) mixed with some yellow birch (*B. alleghaniensis*), balsam poplar (*Populus balsamifera*), mountain-ash (*Sorbus decora*), round-leaved dogwood (*Cornus rugosa*), red-osier dogwood (*C. stolonifera*), and shadbush (*Amelanchier* spp.). Many species of mosses form an extensive ground cover mixed with such species as wild sarsaparilla (*Aralia nudicaulis*), Canada mayflower (*Maianthemum canadense*), dwarf raspberry (*Rubus pubescens*), nude mitrewort (*Mitella nuda*), bluebead-lily (*Clintonia borealis*), dog violet (*Viola conspersa*), and smooth white violet (*V. pallens*). Additional species include starry false Solomon's seal (*Smilacina stellata*), star-flower (*Trientalis borealis*), woodland strawberry (*Fragaria vesca*), twin-flower (*Linnaea borealis*), large-leaved aster (*Aster macrophyllus*), herb-Robert (*Geranium robertianum*), and striped coral-root (*Corallorhiza striata*).

The southern tip of the island and the conifer-covered slopes of the Algoma beach ridge along the eastern shore (Fig. 4) have more drainage. Species growing here include alternate-leaved dogwood (*Cornus alternifolia*), highbush-cranberry (*Viburnum opulus*), rattlesnake-plantain (*Goodyera oblongifolia*), Indian pipe (*Monotropa uniflora*), spotted coral-root (*Corallorhiza maculata*), and fringed polygala (*Polygala paucifolia*). More open situations contain shrubby cinquefoil (*Potentilla fruticosa*), ninebark (*Physocarpus opulifolius*), thimbleweed (*Anemone cylindrica*), wild basil (*Satureja vulgaris*), silverweed (*Potentilla anserina*), strawberry (*Fragaria virginiana*), bearberry (*Arctostaphylos uva-ursi*), marsh skullcap (*Scutellaria galericulata*), and winged cudweed (*Gnaphalium macounii*).

SWAMP FOREST

Profound changes in forest composition can be observed with but a few feet change in elevation. Low depressions on the plateau are often occupied by swamp forest which may include seasonal ponds. In such situations, the dominant trees are white elm (*Ulmus americana*), red maple (*Acer rubrum*), and black ash (*Fraxinus nigra*). Other common associates are white ash (*F. americana*) and yellow birch (*Betula alleghaniensis*), with Michigan holly (*Ilex verticillata*), as a shrub along borders. Common herbaceous plants of this habitat are marsh-marigold (*Caltha palustris*), wild iris (*Iris versicolor*), jack-in-the-pulpit (*Arisaema triphyllum*), jewelweed (*Impatiens biflora*), mad-dog skullcap (*Scutellaria galericulata*), northern bugleweed (*Lycopus uniflorus*), corn mint (*Mentha arvensis*), alpine enchanter's nightshade (*Circaea alpina*), and bladder sedge (*Carex intumescens*). Hummocks and borders are often covered with goldthread (*Coptis trifolia*), Canada mayflower (*Maianthemum canadense*), and dwarf raspberry (*Rubus pubescens*). An interesting species found in this habitat but apparently absent on the Leelanau County mainland is skunk cabbage (*Symplocarpus foetidus*). Other species found in such locations are elliptic shinleaf (*Pyrola elliptica*), sweet-scented bedstraw (*Galium triflorum*), partridge-berry (*Mitchella repens*), wood anemone (*Anemone quinquifolia*), and Pennsylvania bittercress (*Cardamine pensylvanica*).

Common ferns are sensitive (*Onoclea sensibilis*), royal (*O. regalis*), and ostrich (*Matteuccia struthiopteris*) with associates such as grapefern (*Botrychium multifidum*), woodland oakfern (*Gymnocarpium dryopteris*) and ground-pine (*Lycopodium obscurum*). More open locations may also contain broad-leaved cat-tail (*Typha latifolia*) or tall northern bog orchid (*Habenaria hyperborea*).

MIXED FOREST

A mixed woodland is found in certain areas of the island, particularly along the steep banks of the western shore. Typical trees of this sector are red maple (*Acer rubrum*), sugar maple (*A. saccharum*), white birch (*Betula papyrifera*), balsam fir (*Abies balsamea*), white-cedar (*Thuja occidentalis*), and quaking aspen (*Populus tremuloides*). Other scattered species are red oak (*Quercus borealis*), white pine (*Pinus strobus*), choke cherry (*Prunus virginiana*), pin cherry (*P. pensylvanica*), mountain-ash (*Sorbus decora*), mountain maple (*Acer spicatum*), rough-leaved dogwood (*Cornus rugosa*), red-osier dogwood (*C. stolonifera*), white ash (*Fraxinus americana*), and shadbush (*Amelanchier* spp.). Shrubs found in this habitat are bush honeysuckle (*Diervilla lonicera*), snowberry (*Symphoricarpos albus*), poison ivy (*Rhus radicans*) and, in shady situations, Canada yew (*Taxus canadensis*). Common ground cover species are starry false Solomon's seal (*Smilacina stellata*), wild sarsaparilla (*Aralia nudicaulis*), large-leaved aster (*Aster macrophyllus*), evening-primrose (*Oenothera biennis*), common milkweed (*Asclepias syriaca*), Canada bluegrass (*Poa compressa*), bearberry (*Arctostaphylos uva-ursi*), cow-wheat (*Melampyrum lineare*), Canada mayflower (*Maianthemum canadense*), and bracken fern (*Pteridium aquilinum*). In shady situations one may also observe star-flower (*Trientalis borealis*), twin-flower (*Linnaea borealis*), and occasionally Indian pipe (*Monotropa uniflora*), polypody fern (*Polypodium vulgare*), and banded rattlesnake-plantain (*Goodyera oblongifolia*).

DUNES AND SANDY BEACHES

Open dunes are found in the blowout section and the broad sandy terraces at its west border (Fig. 7). Typical sand dune flora is found in these areas and along the sandy beaches of the island. A listing of the species characteristic of this habitat is given below:

Agropyron dasystachyum (dune wheat grass)
Ammophila breviligulata (beach grass)
Aquilegia canadensis (columbine)
Arabis lyrata (lyre-leaved mustard)
Arctostaphylos uva-ursi (bearberry)
Artemisia caudata (dune wormwood)
Asclepias syriaca (common milkweed)
Cakile edentula (sea rocket)
Calamovilfa longifolia (sand reed grass)
Campanula rotundifolia (harebell)
Cirsium pitcheri (Pitcher's thistle)
Cornus stolonifera (red-osier dogwood)
Fragaria virginiana (strawberry)
Juniperus communis var. *depressa* (low juniper)
Juniperus horizontalis (creeping juniper)
Lathyrus maritimus (beach pea)
Lithospermum caroliniense (hoary puccoon)
Oenothera biennis (evening-primrose)
Populus balsamifera (balsam poplar)
Prunus pumila (sand cherry)
Senecio pauperculus (balsam ragwort)
Shepherdia canadensis (buffalo berry)
Smilacina stellata (starry false Solomon's seal)
Solidago deamii (Deam's goldenrod)
Solidago nemoralis (gray goldenrod)
Viola nephrophylla (northern violet)
Zygadenus glaucus (dune lily)

Fig. 7. East-facing view of dune blowout in the southern portion of North Fox Island showing predominance of horizontal juniper (*Juniperus horizontalis*) and ground juniper (*Juniperus communis*).

The vegetation bordering areas of open sand often consists of white-cedar, white birch, and basswood, while round-leaved dogwood (*Cornus rugosa*) and red-osier dogwood (*C. stolonifera*) may also occur. Twin-flower (*Linnaea borealis*) often forms extensive ground cover mats.

MEADOW AND GRASSLAND PLANTS

Species typical of this type of habitat are limited on North Fox because of the scarcity of open areas. Consequently, such plants are found principally in the vicinity of the airstrip and in open situations along the shoreline. Species observed in this habitat type are shepherd's purse (*Capsella bursa-pastoris*), yarrow (*Achillea millefolium*), wild strawberry (*Fragaria virginiana*), common mullein (*Verbascum thapsus*), creeping knotweed (*Polygonum aviculare*), dandelion (*Taraxacum officinale*), mouse-ear chickweed (*Cerastium vulgatum*), curly dock (*Rumex crispus*), white clover (*Trifolium repens*), cut-leaved water horehound (*Lycopus americanus*), Canada bluegrass (*Poa compressa*), cudweed (*Gnaphalium macounii*), field horsetail (*Equisetum arvense*), horseweed (*Conyza canadensis*), thistle (*Cirsium vulgare*), Canada thistle (*C. arvense*), and burdock (*Arctium minus*). In wetter situations one finds baltic rush (*Juncus balticus*), Kalm's lobelia (*Lobelia kalmii*), cattail (*Typha latifolia*), tall northern bog orchid (*Habenaria hyperborea*), Pennsylvania bittercress (*Cardamine pensylvanica*), yellow cress (*Rorippa islandica*), and silverweed (*Potentilla anserina*). Along the borders of such areas one finds red raspberry (*Rubus strigosus*), drooping woodsedge (*Carex arctata*), salmonberry (*Rubus parviflorus*), red-berried elder (*Sambucus pubens*), and bracken fern (*Pteridium aquilinum*).

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FONTINALIS HYPNOIDES NEW TO THE UPPER PENINSULA OF MICHIGAN

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Distribution records of *Fontinalis* (brook moss) in upper Michigan are scanty. Welch, in her 1960 monograph, reported six occurrences of *Fontinalis* in the Keweenaw Peninsula, including *F. antipyretica* var. *gigantea*, *F. duriaei* (*F. hypnoides* var. *duriaei*), *F. flaccida*, *F. novae-angliae* var. *cymbifolia*, and *F. patula*. Darlington (1964) and Crum (1973) added no new records in their treatments of Michigan bryophytes.

We collected specimens of *Fontinalis hypnoides* C. J. Hartm. on rocks in the Manganese River above the Manganese River Gorge, Keweenaw County, and farther upstream in an unnamed tributary near Lake Manganese on October 14, 1973. Voucher specimens are located in the DePauw University Herbarium. A second location with only one small clump on a rock was noted several weeks later in Garden Brook, near Copper Harbor.

Fontinalis hypnoides var. *hypnoides* is a moss reported previously for only one Michigan location: Clarks Lake, Jackson Co., by Purpus, October 1891. *Fontinalis duriaei* Schimp., also known as *F. hypnoides* var. *duriaei* (Schimp) Husn., has been reported for a number of locations in Cheboygan, Emmet, Mackinac, and Presque Isle counties (Crum, 1973). Our specimens appear to be clearly *F. hypnoides* var. *hypnoides* by their narrow leaves, non-auriculate bases and acuminate tips.

Reports of *Fontinalis hypnoides* in the North America are quite rare, with the only collection close to the Upper Peninsula being a questionable one from Wamutosa [Wauwatosa?], Wisconsin, and several sites in nearby Ontario (Welch, 1960). This moss is circumboreal and much more common in Europe than North America (Herzog, 1926: Welch, 1960).

We thank Dr. Winona Welch for verifying our identification.

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WEST AFRICAN PLANT COLLECTIONS AND OTHER BOTANICAL CONTRIBUTIONS OF JERRY GORDON SMITH (1942-1972)

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The productive and promising botanical career of Jerry G. Smith ended prematurely with a cerebral hemorrhage on August 8, 1972. Jerry Smith, a native of Nashville, Michigan, was born February 22, 1942, earned the B.S. in Biology from Alma College in 1965, and the Ph.D. from the University of Michigan in 1971; he had already proven himself to be an imaginative scientist and a popular, inspiring teacher. The catholicity of his interests extended to athletics, music, and the arts; his life was motivated by deep Christian, humanitarian, and family commitments.

Jerry Smith very early began to apply his experimental mind to agriculture, horticulture, and silviculture; his scientific, botanical career began with undergraduate research participation at Alma College. Twice appointed an NSF undergraduate research participant, he first completed and published a pollen analytical study of a late-Pleistocene interstadial deposit from Illinois (1964). Later, as a senior, he turned his attention to the physiological mechanisms and nutrient systems which control the early development of bean (*Phaseolus vulgaris* L.) embryos. This research interest continued through his doctoral dissertation (1971) at the University of Michigan (Dr. Peter Kaufman, adviser) and to a postdoctoral appointment at Yale University with Professor Ian Sussex in 1971-2.

During his junior year, he was selected as the Alma College Africa Fellow, the pioneer participant in a program in which an Alma student each year teaches at the Mayflower School at Ikenne, near Shagamu, Western State, Nigeria. This residential secondary school is committed to an educational philosophy of total student development and wholeness and to self-sufficiency; it is among the most selective schools in Nigeria. Beyond his teaching contribution, Jerry's athletic, botanical, and agricultural talents contributed abundantly to the school, most notably to the initiation of the breeding of pigs.

During his year of residency in the tropical forest zone of Nigeria and on trips to the drier regions of the Northern State and adjacent Niger, Smith made collections of native and introduced plant species. These served as the basis of his senior thesis at Alma College (unpublished, 1965). These specimens, numbering about 330 collections, have recently been deposited at the University of Michigan Herbarium, Ann Arbor, where they are available for study; many remain unidentified.

Jerry Gordon Smith was the 1965 recipient of the Barlow Trophy, the highest senior honor at Alma College, and was awarded both a National Science Foundation Fellowship and a Danforth Foundation Fellowship for graduate studies. His doctoral research was supported twice by grants from the American Cancer Society. While a graduate student at Ann Arbor he taught frequently and inspired other prospective graduate students through the Michigan Scholars program. He taught biology at Alma College from January, 1969, to June, 1971, and had accepted a teaching position at Hamline University which was to have begun a few weeks after his untimely death.

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Jerry Gordon Smith
1942-1972

Reviews

FUNGI THAT DECAY PONDEROSA PINE. By Robert L. Gilbertson. University of Arizona Press, Tucson, Arizona. 1974. x + 197 pp. $9.50.

Dr. Gilbertson, who is a member of the faculty of the University of Arizona and well known for his work in mycology and forest pathology, has focused this manual of decay organisms on the basidiomycetes found on wood of ponderosa pine in Arizona and New Mexico. Two hundred of the included species were collected in this two-state region, and the remaining 28 had been previously reported on the same substrate from the Pacific Northwest, mainly by C. G. Shaw and D. P. Lowe. People interested in these particular fungi should not be too concerned about the apparent geographical and ecological limitations of the manual, however, for some of the species are distributed over a much greater area and occur on the wood of other trees, both coniferous and deciduous. Furthermore, ponderosa pine is grown as an ornamental and plantation tree in places, such as Michigan, outside its natural range in western North America.

This manual, presented in an attractive format and paperbound, is introduced by brief discussions of the distribution and economic importance of white pine and the ecological and commercial significance of wood-decaying fungi. The taxonomic part begins with a check list and proceeds with keys to and descriptions of the included taxa. The well-constructed keys can be easily followed. The descriptions are both precise and concise, and each species is illustrated by excellent line drawings of microscopic structures (tramal hyphae, cystidia, basidiospores, etc.) made from one of the specimens cited.

Several jelly fungi and agarics are treated in the manual, but most of the included species are polypores, tooth fungi, and simple hymenomycetes, i.e., organisms that Dr. Gilbertson, as well as others, places in the Order Aphyllophorales. The taxonomic system used for this order is thoroughly modern, following M. A. Donk at the family level and E. Parmasto for the subfamilies of the Corticiaceae. This means that the characters emphasized at these taxonomic levels are those of microscopic structures and chemical color reactions. For people not familiar with the details involved here, the glossary near the end of the manual will be most useful.

—Robert L. Shaffer

ENVIRONMENTAL STATUS OF THE LAKE MICHIGAN REGION VOLUME 10. VEGETATION OF THE LAKE MICHIGAN DRAINAGE BASIN. By Forest Stearns and Nicholas Kobriger. Argonne National Laboratory, Argonne, Illinois. 1975. 113 pp. $5.45 (ANL/ES-40 Vol. 10, from National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia 22161), paper cover.

Part of a series describing the status of Lake Michigan and its watershed as background for assessing environmental impact of nuclear power plants, this report describes the original vegetation, present plant communities, and processes of succession in an area much of which lies in Michigan. A comprehensive view such as this is valuable to have, although it is based in large part on a miscellaneous selection of published literature and maps and consequently is a bit spotty, especially when various antique Michigan references are relied upon (e.g., citation of a 1904 abstract by Burns to document that in Michigan the common bog mat *Carex* is *C. filiformis* whereas in Wisconsin it is *C. lasiocarpa*—when these names have in fact been applied to the same species, as should have been clear from Gates 1942 or many other more substantial references).

—E.G.V.

Editorial Notes

INDEX: There is no index to Volume 14. As in the past, there will be a cumulative index covering three volumes. Libraries and other subscribers who bind their copies should note that the next triennial index will be at the end of Volume 15, so that Volumes 13-15, with their index, will make a suitable unit for binding.

ERRATUM: In the January issue, Vol. 14, No. 1, p. 30, lines 6-9 belong on p. 37, under the Ranunculaceae.

MAILING DATE: The May number (Vol. 14, No. 3) was mailed May 16, 1975.

Publications of Interest

LAKE SUPERIOR'S NORTH SHORE. Ontario Naturalist Vol. 14, No. 4, December 1974. 48 pp. $1.00 (from Federation of Ontario Naturalists, 1262 Don Mills Rd., Don Mills, Ontario). This special issue of the increasingly attractive and colorful *Ontario Naturalist* is a "plain tribute to one of the most splendid and historically vibrant regions of the province, and a modest attempt to present some aspects of the struggle for its preservation." Much of the material, including an article on botanical aspects, deals with Lake Superior Provincial Park.

SEEDS OF WOODY PLANTS IN THE UNITED STATES. C. S. Schopmeyer, technical coordinator. U.S. Department of Agriculture, Handbook No. 450. 1974. 883 pp. $13.60 (Government Printing Office). This volume supersedes the long out-of-print *Woody-Plant Seed Manual*, published in 1948. Part 1 includes much material on general seed biology and a section of color photos for species "for which [fruit] color is a criterion of ripeness." Part 2 contains specific information on seeds of 188 genera of native and introduced trees and shrubs, including illustrations and data on occurrence, phenology, seed collection, germination, etc.

A FIELD GUIDE TO WESTERN MUSHROOMS. By Alexander H. Smith. University of Michigan Press, Ann Arbor. 1975. 280 pp. $16.50. Here is the eagerly awaited companion volume to *The Mushroom Hunter's Field Guide* (sales of which have passed a landmark 100,000 copies). Similar in shape and format and usefulness, it is completely illustrated in color, dealing with slightly over 200 species "found especially in the area west of the Great Plains in North America" (but obviously specializing in Idaho, Washington, Oregon, and northern California—with little if any mention of, say, Arizona, New Mexico, Utah, or British Columbia). Since many of the northern species included range eastward as well, the volume will be of some use in the Great Lakes area. There is a helpful introduction, and clear information for each species on field identification, microscopic characters, habitat ("When and where to find it"), and edibility (if known or reported).

TOWARD A WETLAND CLASSIFICATION FOR ONTARIO. By J. K. Jeglum, A. N. Boissonneau, and V. F. Haavisto. Inf. Rep. O-X-215, Great Lakes Forest Research Centre, Canadian Forestry Service, Box 490, Sault Ste. Marie, Ontario P6A 5M7. 1974. 54 + [40] pp. This report presents a practical, illustrated hierarchical classification of marshes, bogs, fens, and swamps, stressing vegetational physiognomy and dominance of vegetation, with emphasis on the wetlands of the Northern Clay Section of Ontario.

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(On the cover: Erosion by Lake Michigan fells a beech tree. Photo by Daniel L. Pokora south of Grand Haven, Ottawa County, Michigan, October 1972).

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ACROSS MICHIGAN BY COVERED WAGON: A BOTANICAL EXPEDITION IN 1888

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In June of 1888, an exploring expedition, concerned with the botany, forestry, and agriculture of the region traversed, crossed the northern portion of the Lower Peninsula of Michigan, from Harrisville to Frankfort. Little-known today, the expedition was widely reported upon by contemporary newspapers; information derived from it appeared in various publications afterwards; over 300 specimens collected are in the Beal-Darlington Herbarium of Michigan State University and over 100 in the herbarium of the Bailey Hortorium at Cornell University, with smaller numbers in other herbaria. From these sources, with supplementary aid from historical literature, maps, advice from local historians, and a field trip retracing the route, we have attempted to reconstruct the course of this pioneering scientific endeavor in the state.

The personnel of the exploring party helped to guarantee its scientific distinction,[2] and as the Detroit *Free Press* reporter accompanying the group began his first dispatch: "Of course, it is necessary to introduce the party." Introducing them with the perspective of subsequent decades of history and with a point of view more botanical than journalistic, we can supplement the accounts, which will follow, from the *Free Press*:

WILLIAM J. BEAL[3]

William James Beal (1833-1924), a native of Lenawee County, Michigan, was a graduate of the University of Michigan (A.B., 1859; A.M., 1862; Ph.D. [hon.], 1880) and of Harvard (B.S., 1865), where he studied with Asa Gray and Louis Agassiz. In July of 1870 he was appointed Professor of Botany, and two years later also of Forestry, at the Michigan Agricultural College (now Michigan State University). Asa Gray wrote to him, prophetically, in March of 1871: "I am glad you are established in Michigan. You will bring up botany . . . in all that region" (Baker & Baker, 1925, p. 7). In the truest sense, he was—to use the trite expression of today—an "innovative" teacher, stressing laboratory experience and the necessity for observation. Among his diverse interests were the grasses. In 1887, the year before the expedition, he published at his own expense the first volume of his *Grasses of North America* (the second volume of which

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[1]Present address: Department of Botany and Plant Pathology, University of New Hampshire, Durham, New Hampshire 03824.

[2]Three of the five botanical members of the party (Bailey, Beal, and Dewey) were already starred in the first edition of *American Men of Science* (1906) as among the 100 leading botanists (1000 scientists in all) of the nation, and a fourth (Wheeler) was listed.

[3]See Anon. (1924), Baker & Baker (1925), Beal (1915, pp. 414-415), M.S.U. (1973).

readily found a publisher in 1896). It is not surprising that grasses were much on his mind in 1888, during which year he chaired section F (botany) of the American Association for the Advancement of Science. In 1904 (published 1905), he completed a revision of previous checklists of Michigan vascular plants, and that "Michigan Flora" stands as the most recent effort to list all these plants in the state. In the introduction to this work, Beal mentions: "In 1888, Professor L. H. Bailey, C. F. Wheeler and the author accompanied by two students spent two weeks in collecting on a journey across the State from Harrisville in Alcona county to Frankfort in Benzie county."

LIBERTY HYDE BAILEY[4]

Liberty Hyde Bailey (1858-1954), at the time of this expedition, was becoming the leading authority on the sedge genus *Carex* in North America. A native of South Haven, Michigan, he graduated from the Agricultural College in 1882, his accomplishments having included not only outstanding academic work with Beal but also a "flair for journalism" (Rodgers, 1949, p. 52). He founded and edited *The College Speculum,* a quarterly (later monthly) which survived until 1895. Following graduation, he worked for a few months as a newspaper reporter in Springfield, Illinois, quickly earning the respect of his editor. The cub reporter "combined keen observation and accuracy with dramatic verve, wrote swiftly under pressure, and had no trouble fitting his copy to the available space" (Dorf, 1956, p. 43). In February of 1883, on Beal's recommendation, he became a special herbarium assistant to Asa Gray at Harvard, where he had some time for botanical studies including pursuit of a long-standing interest in *Carex,* on which his first paper was published in 1884.

Early in 1885, Bailey returned to his alma mater as Professor of Horticulture and Landscape Gardening—the Agricultural College having established the first such chair in the country. At M.A.C. he was recognized as a highly effective teacher, spellbinding students in all fields, not botany or horticulture alone, and working with them in the field. His life-long career as a public lecturer and as a prolific author and editor of botanical and horticultural publications was well on its way. In 1886, his 100-page synopsis of North American species of *Carex* was published. In the spring of 1888, Bailey accepted appointment to a newly established professorship in practical and experimental horticulture at Cornell University, to begin in the fall with a tour to study European horticultural work. Bailey was thus rather a "lame duck" professor at the Michigan Agricultural College in the summer of 1888, and the expedition with Beal and others was his last major activity in the state before going to Cornell—where he ultimately became Dean of a new College of Agriculture.

In early June of 1888 Bailey accepted an invitation from Sereno Watson to revise *Carex* for the sixth edition of *Gray's Manual* (Watson & Coulter, 1889). The European tour, on which he left in August of 1888, afforded an opportunity not only to visit experiment stations and horticultural research but also to examine type specimens of North American species of *Carex* in European herbaria. With manuscript for the *Carex* revision due in January and Bailey not

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[4]See Rodgers (1949), Dorf (1956), Lawrence (1955).

expecting to be settled in Ithaca until about January 1 (Rodgers, 1949, p. 121), one imagines that a good deal of the revision was drafted in Europe and on shipboard! In May of 1889 the first number of the new series, *Memoirs of the Torrey Botanical Club,* consisted of Bailey's report on *Carex* types; the notes on several species refer to observations and collections in Michigan, some of them attributable to the 1888 expedition, e.g., *Carex communis* var. *wheeleri,* described as new, named for C. F. Wheeler, and mentioned from Alcona County, Michigan.

Bailey was in frequent correspondence with Watson at the Gray Herbarium, and from these letters came the only references to the 1888 expedition in Rodgers' exhaustive biography of Bailey.[5] In a letter of July 4, 1888—hardly two weeks after he returned to Lansing for a quick trip to Cornell—Bailey wrote Watson (Rodgers, 1949, p. 113):

> I take the liberty to send you by express, prepaid, a small parcel of plants for examination. Dr. Beal, C. F. Wheeler, and myself have made a botanizing trip across Michigan in the jack pine plains region, and the few things I send are mostly from this collection . . .

In October, Bailey wrote to Watson from Stockholm (Rodgers, 1949, p. 122):

> I am just in receipt of a note from Dr. Beal giving your determinations of some of our plants from the pine barrens of Michigan. I am particularly interested in the little violet, because it appears to be a very distinct variety . . . If you think it worthy a variety name, please call it Wheeleri, for Mr. Wheeler first collected it, and he deserves to be remembered in our state flora.

CHARLES F. WHEELER[6]

Charles Fay Wheeler (1842-1910) lived in New York state until the Civil War. He attended medical courses at the University of Michigan 1866-1867, but then operated a drug and book store in Hubbardston (Ionia County), Michigan. He was the state's leading "amateur" botanist, of professional stature. In 1881 he collaborated with Erwin F. Smith, also of Hubbardston,[7] in producing the first annotated list of vascular plants for the entire state. In 1892, Beal and Wheeler revised this work, for which Beal prepared the last revision (1905). In the meantime, Wheeler decided to devote himself fully to botany, entering the Agricultural College in 1889 and receiving his B.S. in 1891. (His alma mater honored him with an Sc.D. in 1907.) He had assisted Beal as an instructor in botany since 1890, and in 1892 he assumed the duties previously held by Beal as Botanist for the Experiment Station. From 1895 until 1902, when he left for

[5]The other book-length biography of Bailey (Dorf, 1956) confuses the 1888 Michigan expedition with an 1886 one to northern Minnesota, in which Bailey participated. Dorf's quotation (p. 57) from a newspaper reporter refers to the 1888 trip, not to the 1886 one.

[6]See Rodgers (1949, p. 57; 1952, pp. 10-30), Wight (1910), and note 19.

[7]Erwin Frink Smith (see Rodgers, 1952) studied independently and at the Agricultural College, but received his B.S. in 1886 from the University of Michigan after a year of residence. In 1889 he received his doctorate from the same school, for his work on the peach yellows disease. The "Dean of American plant pathologists," he was a close friend of Bailey's. (Bailey visited Wheeler and Smith in Hubbardston during his freshman year at M.A.C.–1877-1878.)

the U.S. Department of Agriculture in Washington, Wheeler held the title of Assistant Professor; references to him as "professor" in 1888 were premature.

Beal and Wheeler's 1892 "Michigan Flora" included many distributional records attributable to the 1888 expedition. Wheeler's own extensive herbarium of 7100 specimens, just purchased by the Agricultural College for $600, was destroyed by fire when the Botanical Laboratory burned on March 23, 1890, although most of the College herbarium was saved. Wheeler's collection of *Carex* (numbering 3636 specimens) was purchased by the Gray Herbarium from his widow in 1910.

Bailey (in Wight, 1910) wrote of Wheeler: "He seemed to have an eye for critical things and for those that escaped common observation. . . . and if any plant was rare he was sure to find it if it grew within his range. . . . I have never known a more modest and unassuming man. . . . His keen eyes saw everything, and he enjoyed nature to the full." Wheeler and G. H. Hicks (see note 57) "working with Dr. Beal were responsible for the development of the botanical garden and the herbarium" at the Agricultural College (Wight, 1910).

LYSTER H. DEWEY[8]

Lyster Hoxie Dewey (1865-1944), a native of Lenawee County, Michigan, was one of the two senior students at the Agricultural College who accompanied the expedition in 1888. (They received their B.S. degrees at the regular August commencement exercises.) Dewey continued to assist Beal as an instructor in botany until September of 1890, when he "was selected after a thorough examination, with six competitors, as the successful candidate, for assistant to the botanist" for the U.S. Department of Agriculture in Washington. Dewey was in charge of fiber-crop investigations until his retirement from the U.S.D.A. in 1935 and authored many papers on the fiber properties of *Cannabis* and other plants.

DANIEL A. PELTON[9]

Daniel Alvin Pelton (1865-1926) was born in Chagrin Falls, Ohio, but his home was in Hillsdale County, Michigan, at the time he was a student. Following his graduation in August of 1888, he was employed as clerk for the State Board of Health in Lansing, during which time he did extensive reading in medical books in the Board library (1888-1891, as noted in Rep. St. Board Health Mich.). He graduated in 1897 from Barnes Medical College, St. Louis, Missouri. He practiced briefly in Texas and Missouri but chiefly in Arkansas (Jonesboro about 1902-1912; Forrest City until his death there March 29, 1926). Apparently Pelton maintained some interest in botany and in his alma mater, to which he presented 1900 herbarium specimens in 1892 and additional specimens in 1923.

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[8]See Science 100: 513 (Dec. 8, 1944); Rep. St. Board Agr. Mich. 30: 39 (1892 ["1891"]).

[9]For information about Pelton, we are indebted to Victoria Elsner of the American Medical Association Division of Library and Archival Services and to the Archivist of the Medical Library, Washington University School of Medicine.

OTHER MEMBERS OF THE PARTY

In his report for the year ending June 30, 1888, Beal (1889, p. 179) described very briefly the expedition and listed its scientific personnel. In addition, "The editors of the *Free Press* and the *Tribune*, of Detroit, saw and were ready to improve an opportunity to gather information for their readers. Mr. Fisher, of the former paper, and Mr. H. Parish, of the latter, were most gladly welcomed as members of our party. W. W. Metcalf, of Grayling, was our teamster, and in many places also served as a guide through parts of the newly settled country, where it is often difficult to decide which is the highway and which is a road to some farmhouse or lumber camp." These three persons plus the five botanists made a total party of eight (see cover photo).

The first four dispatches in the *Free Press* were anonymous but presumably written by Fisher, the last one being dated at Mio June 15. The next three, and lengthy, dispatches were initialed "L. H. B." and erstwhile journalist Bailey evidently saved the day for the *Free Press* when its own reporter became diverted in Mio (see note 40). The *Tribune* stories are fewer and briefer. All are initialed "H. P." The last is datelined Kalkaska County June 21. Bailey returned to Lansing from Fife Lake and apparently the *Tribune* reporter left the expedition at the same time. The final *Free Press* dispatch, dated Frankfort June 25, is anonymous but may have been written by Wheeler. It mentions that the party was "now reduced to five" and these would thus be Beal, Wheeler, Dewey, Pelton, and Metcalf.

We have not been able to document the presence of any other persons on portions of the trip, although Beal (1893, p. 82) stated that the "party consisted of eight to ten persons." Beal later (1915, p. 88) noted that the reporters were with the party "for nearly the two weeks of the journey and wrote a column or more daily" and this, too, seems to be an overstatement resulting perhaps from a dim memory (as likewise the indication, at the same time, that the trip was made in May). (See note 22 for additional comment on personnel.)

SPONSORSHIP AND PURPOSES OF THE EXPEDITION

The exploring party was evidently the idea of Beal, who consistently credited the Agricultural College president, Edwin Willits, with prompt support:

> As the timber was rapidly disappearing in northern Michigan, considerable discussion arose as to the value of these stump or cut-over-lands. The writer made a suggestion to President Willits that Professor Bailey and himself, with two or three others, make a trip across the state in May from Harrisville in Alcona county to Frankfort in Benzie county. Instead of opposing the scheme on account of the expense or for any other reasons, President Willits believed it would be profitable and soon decided that the College should pay half the expense and the Experiment Station half. (Beal, 1915, pp. 87-88)

Beal also notes that President Willits on his own initiative personally visited with the editors of the Detroit newspapers and persuaded them to send reporters. (The Democratic *Free Press* and the Republican papers, including the *Tribune*, were constantly exchanging editorial barbs, and perhaps their reporters found themselves incompatible in the same covered wagon! Cf. note 40.)

Attention should be called to one "important object" of the expedition stated in the initial dispatch to each newspaper but never again mentioned. This was to investigate a suitable area four or six townships in size (i.e., over 92,000 or 138,000 acres!) "in the yet untouched and wildest portion of the state, which shall be also typical, and letting all game and other animals live there in perfect peace and quietness: have a sort of state park, in fact" (*Tribune*, June 13, 1888). Inspired by the recent reservation of Yellowstone as a national park, and mindful of the need for watershed, game, and forest protection, Michigan residents were expressing wide support for such a state park at the time. It would "afford an opportunity to study all kinds of wild plants in portions of virgin forests for many years to come" (Beal & Garfield, 1888, p. 79; cf. also pp. 20-21 and Rep. St. Board Agr. Mich. 27: 352-354. 1889). Such a preserve was thought possible in the headwaters of the Manistee, Muskegon, and Au Sable rivers. Today, we can only mourn that it was never established!

The State Legislature on June 27, 1887, approved an Act to establish an Independent Forestry Commission, which was "to institute an inquiry into the extent to which the forests of Michigan are being destroyed by fires, used by wasteful cutting for consumption or for the purpose of clearing lands for tillage or pasturage. Also as to the effect of the diminution of the wooded surface of the land upon ponds, rivers and water power of the State, and in disturbing and deteriorating the natural conditions of the climate. Also as to the protection of denuded regions, stump and swamp lands." An appropriation of $1,000 was made for expenses and a report was to be submitted to the legislature 60 days before its 1889 session; the Act was repealed June 12, 1891. A Forestry Convention was held in Grand Rapids in January of 1888 at which many proposals were aired in regard to protective legislation and the need for reserves (see Beal & Garfield, 1888). In October of 1887 the Forestry Commission was established, its officers consisting of two Directors, W. J. Beal and C. W. Garfield,[10] with president, secretary, and auditor from the State Board of Agriculture. In the same year, the U.S. Congress passed the "Hatch Act," signed by President Cleveland March 2, 1887, which established an agricultural experiment station in each state, to be supported by federal funds of $15,000 a year. Thus, in 1888 there was both state and federal support available, which shared the expenses of the timely expedition across Michigan.

THE ROUTE

The principal source for determining the route taken by the party is the newspaper accounts, that in the *Free Press* being the most detailed. Localities on specimen labels help to document various sites along the way. Many of the communities visited were very new; some recent post offices were served by

[10]Charles W. Garfield, an 1870 graduate of the Agricultural College and former assistant of Beal's, was a vigorous proponent of sound agricultural and forestry work in Michigan. A banker in Grand Rapids, he was a member of the State Board of Agriculture. He was probably responsible for Bailey's return to M.A.C. from Harvard—and again for Bailey's invitation to Cornell; indeed, Garfield had had an important role in persuading Bailey to go to college in the first place (Rodgers, 1949, pp. 17, 114, 119). Garfield is also to be credited with having Wheeler and Smith's Flora published in the report of the State Horticultural Society (Rodgers, 1952, p. 21).

stagecoach thrice weekly or less often. Lumbering was in its heyday.[11] Railroads had been moving into the northern part of the state; wagon roads were few. *Tackabury's Atlas of the State of Michigan* (Walling, 1884) shows wagon roads on maps with section lines for all counties, and the Page volume on *The Traverse Region* (1884) seems even more complete for Kalkaska, Grand Traverse, and Benzie counties; we have relied heavily on these for details of the route. In many instances there was apparently no choice as to the road from one point to another. In western Grand Traverse County and in Benzie County, there were more roads and the newspaper accounts are more vague, so we cannot be quite as certain of the exact roads selected. Some roads undoubtedly were made between the 1884 maps and the 1888 trip; in fact, *Tackabury's Atlas* does not indicate any connection between Crawford and Kalkaska county segments of the journey. With the aid of localities actually cited on labels and the advice of local historians, we show the route as best we can interpret it in Fig. 1 (see also note 72). A brief summary of the expedition's course follows, with special reference to localities visited:

Monday, June 11: Arrived by rail at West Harrisville [= Lincoln], Alcona County; covered wagon on corduroy road to Harrisville for the night.

Tuesday, June 12: Collected around Harrisville and Sturgeon Point; camped for the night in the forest at West Harrisville.

Wednesday, June 13: Rain all morning; dinner at Mud Lake [= Barton City]; Alger lumber camp a short distance west of Mud Lake; camped for the night at Potts Farm in western Alcona County.

Thursday, June 14: Took shelter from severe thunderstorm about 10:00 a.m. in the "Block House," a tavern on the eastern edge of Oscoda County; passed Potts Headquarters [= McKinley] and had dinner at Comins Farm on the Au Sable; spent the night in hotel in Mio.

Friday, June 15: West from Mio through the pine barrens; collected at Ryno, Harmon Tp., and at Dr. O. Palmer's farm (6 mi. west of Ryno), Oscoda County; camped for the night at Frazer's [on North Branch of Au Sable River, 2 mi. into Crawford County].

Saturday, June 16: Passed Appenzell [= Sigsbee] and arrived at Grayling at 3:00; camped on the edge of the village, near the home of wagon driver Metcalf, who was deputy sheriff of Crawford County.

Sunday, June 17: Beal visited experiment farm in morning; left Grayling about 4:00 for short trip of four miles to Portage Lake [= Lake Margrethe], where camped for the night.

Monday, June 18: Dinner at Dempsey's lumber camp in Glade Tp. [T25N, R5W] in southeastern Kalkaska County; collected at Fletcher and elsewhere in same township; camped for night in Calkins' clearing at Jam One [= Sharon] on the Manistee River.

Tuesday, June 19: Crossed Kalkaska County, collecting in Garfield Tp. [T25N, R7W]; impressed with bog east of Fife Lake and after a two-hour drenching storm, arrived "wet but happy" at Fife Lake [barely into Grand Traverse County]; apparently spent the night in a hotel in Fife Lake.

Wednesday, June 20: Bailey returned to Lansing; rest of party passed through Paradise Tp. [T25N, R10W], including Kingsley, and Mayfield Tp. [T25N, R11W]; then turned north and camped at a farm in Green Lake Tp. [T26N, R12W] in the low country south of Traverse City.

Thursday, June 21: Turned west toward Benzie County; dinner at "Central House" in

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[11]The peak lumbering year in Michigan (4½ billion feet) was 1890 (Beck, 1958, p. 13); of the 4 billion feet harvested in 1887, nearly a quarter million went down the Au Sable alone and almost as much down the Manistee—the two principal rivers observed by the expedition (Fitzmaurice, 1889, p. 51; Maybee, 1959, p. 416).

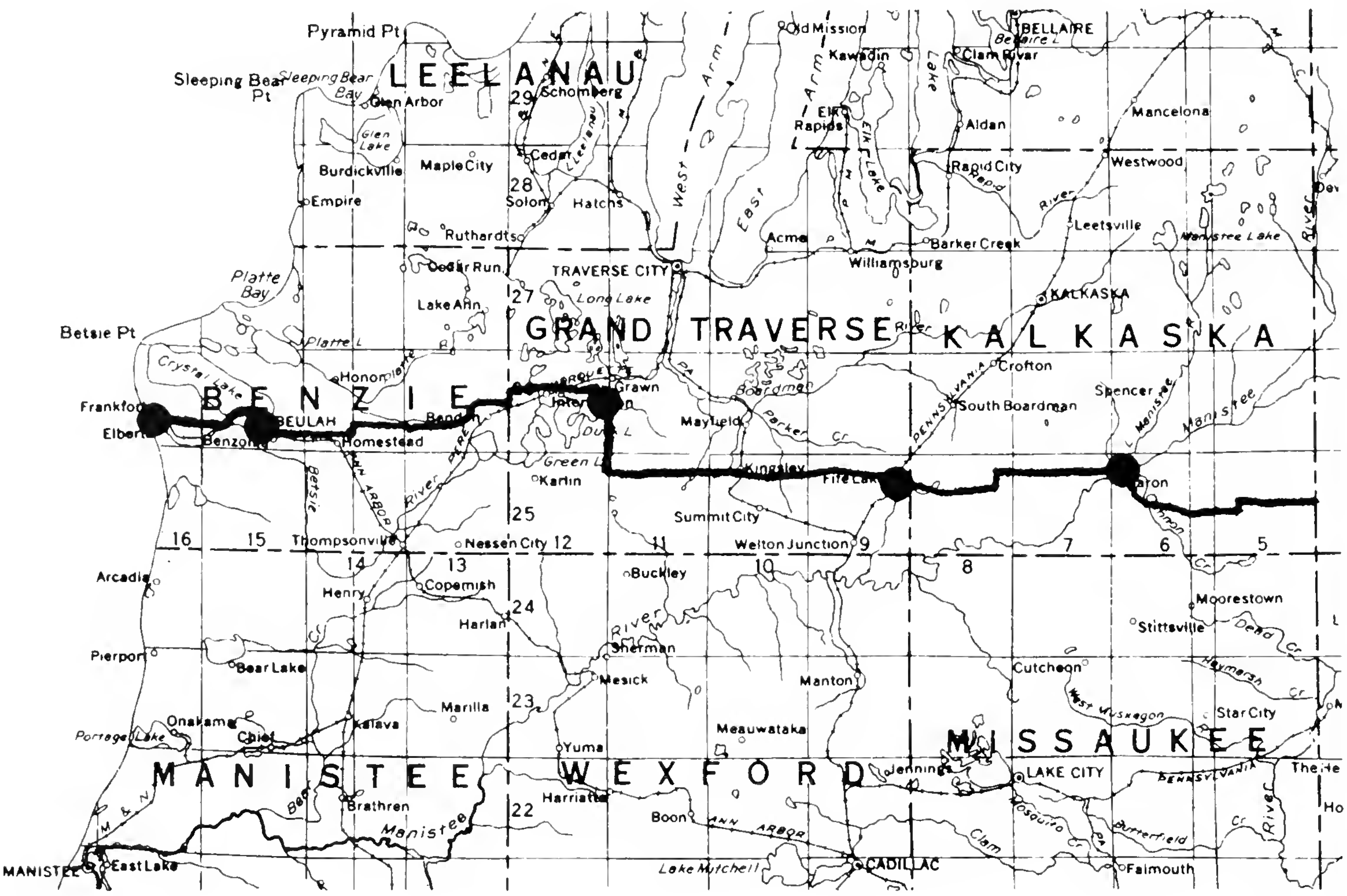


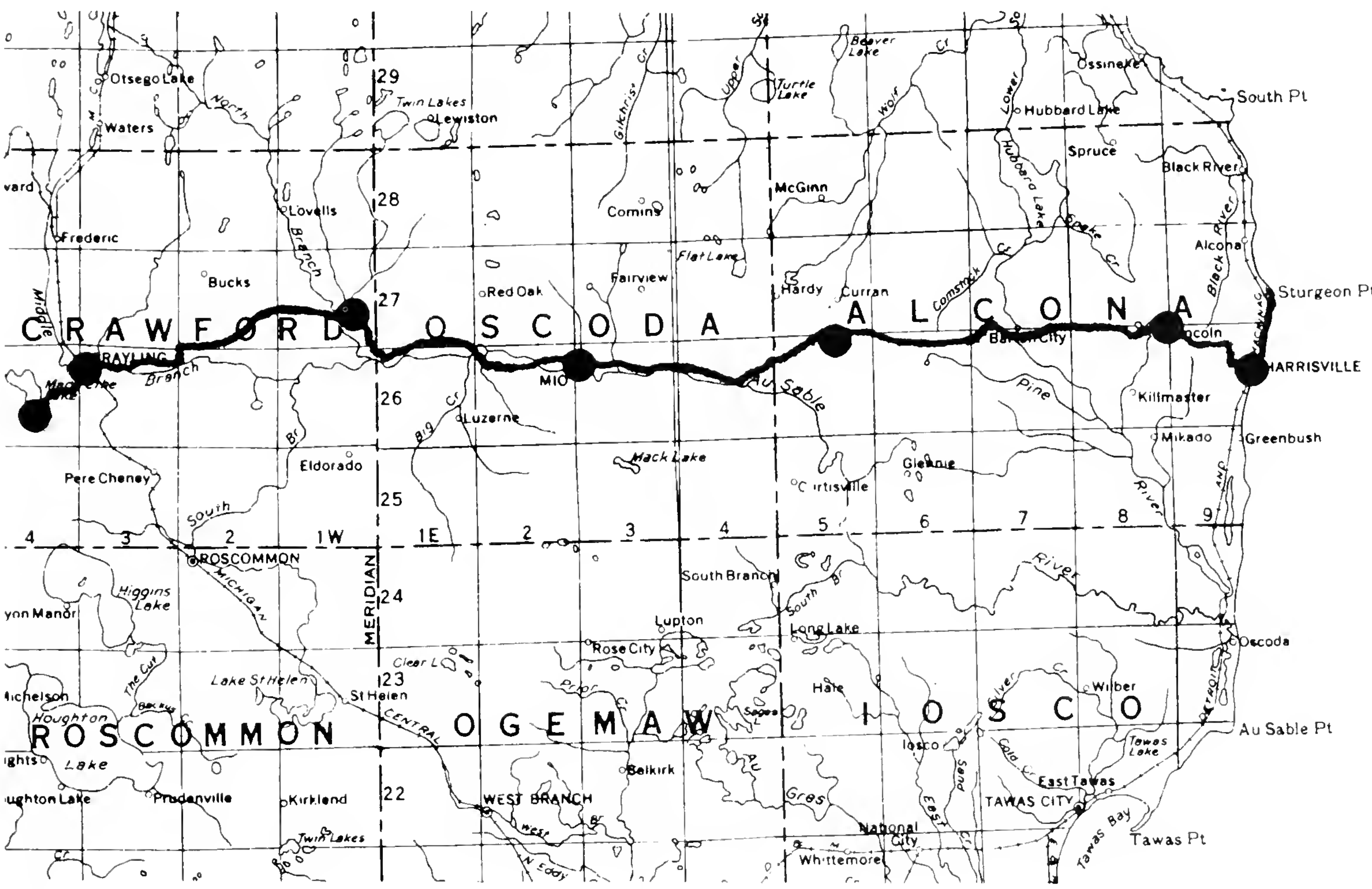
Fig. 1. Map showing the route taken by the 1888 exploring expedition, based on all sources of evidence, as described in the text (note 66 explains the gap in western Crawford Co.). The basic grid pattern shows survey townships, 6 miles on a side (lines of longitude 84°, 85°, & 86° W also pass vertically across map). Townships north of the Base Line are indicated (T25N, T26N, etc.) along the border between Oscoda and Crawford counties, which follows the Michigan Meridian, from which, along the south border of the counties, one may read the rangeline numbers (e.g., Glade Township in 1888 was T26N, R5W—the southeasternmost township in Kalkaska County). (Base map by U.S. Geological Survey, 1932.)

Inland Tp. [T26N, R13W]; collected in Inland Tp. and Homestead Tp. [T26N, R14W]; arrived at Benzonia in the evening, and camped for the night on the shore of Crystal Lake.

Friday, June 22: Continued to Frankfort before breakfast; spent the day exploring the shore and sand dunes along Crystal Lake and Lake Michigan; night presumably spent in Frankfort.

Saturday, June 23: Returned to Lansing, via Manistee, arriving at the College at night.

In June of 1975, we attempted in a modest way to retrace the route of the expedition. In a bipartisan spirit, the party included one botanist each from Michigan State University and The University of Michigan, the latter doubling as wagon driver (Jeep station wagon, not a prairie schooner). No reporters accompanied the trip. One senior student joined us, or more accurately, one May honors graduate of The University of Michigan, Robert Marquis. For the most part, the roads which we calculated were taken in 1888 were now either much better or much worse (ranging from non-existent to federal highway), but we adhered to them whenever possible. We left Harrisville on June 12, exactly 87 years after the pioneering expedition, but moved more rapidly and arrived in Frankfort June 16. Results of searching for collecting sites and of conversations with local historians are reflected in the footnotes. (See also Figs. 16-19.)



Circles along the route mark the daily progress of the expedition by indicating where the party spent each night; from east to west, these locations are

June 11: Harrisville
June 12: West Harrisville [Lincoln]
June 13: Potts Farm
June 14: Mio
June 15: Frazer's
June 16: Grayling
June 17: Portage Lake [Lake Margrethe]
June 18: Jam One [Sharon]
June 19: Fife Lake
June 20: Green Lake Tp. farm
June 21: Crystal Lake
June 22: Frankfort

REPORTS AND COLLECTIONS

Beal (1899, pp. 103-104) summarized the expedition in a single paragraph, asserting that "Four hundred species of plants were collected and a full report of the results embodied in my report for 1888." We have located specimens of only about 60% of the alleged 400 species, although many are represented by more than one collection. The "full report" in Beal's 1888 report (1889, see pp. 179-193) included much information of interest but was hardly "full." Beal gave "short notes on a few plants found during the summer" but thought it "unwise" to print a complete list. Even the notes on the 42 species listed were not restricted to observations made during the June trip. Short species lists were also provided to indicate the flora of the jack pine plains and to illustrate comparisons between the east and west sides of the state at the latitude of Harrisville and Frankfort, although again observations from later in the season were apparently taken into account. L. H. Dewey contributed to Beal's report two full pages (186-188) on "Animal Life in the Pine Woods." Perhaps the insects have changed the least in the past nine decades. Dewey observed: "Among insects, mosquitoes were numerous, by far surpassing all other species. Sand flies were occasionally felt. Spotted-winged deer-flies were abundant and hungry." The grayling, an extinct fish for the past half-century, was already becoming rare in 1888 (see note 76). On the jack pine plains, "the only bird found was the robin" (see note 53), although others were seen in better habitats, including one sandhill crane "on the Manistee" and evidence of pileated woodpeckers from "Grayling through to Lake Michigan." Beal concluded his report by reprinting major selections from Bailey's dispatches published in the *Free Press* for June 21 and June 23.

The report of the State Forestry Commission (Beal & Garfield, 1888), as might be expected, draws heavily on observations made during the expedition, but defers to Beal's report for "an account of the organization of a party and their trip across the State in June, for the purpose of studying the forestry and agricultural possibilities of the region traversed." The Beal-Garfield report is of special interest, however, for including several drawings made from photographs taken on the expedition. These are not specifically identified, and there are illustrations from other sources as well. But many do match photographs taken presumably by L. H. Bailey, who served as photographer on the expedition. (See *Free Press* reports on June 16 and June 17.) Some of the photographs are extant in the Michigan State University Archives and Historical Collections, and we reproduce a few of them with this account, apparently for the first time. A number of the original glass-plate negatives are still in the safekeeping of the Beal-Darlington Herbarium at Michigan State University. As Beal wrote (1915, p. 88): "With the photographs taken and reports made was not the exploration profitable?"

The only notes explicitly based on the trip seem to be a list in Bailey's hand in the files of the Beal-Darlington Herbarium. This consists of three sheets, with numbers 25 through 109, listing species, locality, month, and day. Evidently the first page is missing. Pinned to the list is a small note also in Bailey's hand: "Here are some notes I found on our northern collections. They may be some use to you." Added in Wheeler's hand is "L. H. Bailey–1890." We cite this document henceforth as "Bailey's List." In the lists of species collected at the various localities, we give Bailey numbers in parentheses if they appear on the label, and in square brackets if we add them from Bailey's List.

As the fullest account of the expedition, the dispatches published in the Detroit *Free Press* are reprinted at this time, unabridged, with the principal headlines under which each appeared (not all subsidiary heads). The date and page of publication are given in brackets above each headline. The insight of the reporters, including experienced journalist Liberty Hyde Bailey, into agricultural and forestry practices as well as the natural history of the region are valuable accounts of record. The *Tribune* reports[12] are quoted in footnotes whenever they add something of special interest.

Several other newspapers carried some word of the expedition. The Detroit *Evening News* for June 13, under the heading "A State Botanical Junket," summarized its initiation:

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[12]Dates, pages, and principal headlines of the *Tribune* articles are as follows: June 13, 1888, p. 3, "With Howling Wolves"; June 14, p. 3, "Off for Pine Barrens"; June 16, p. 1, "Excellent Farm Lands"; June 18, p. 4, "In Jack Pine Plains"; June 21, p. 8, "Scientific Wanderers"; June 22, p. 8, "Living in the Woods."

> Dr. W. J. Beal, Prof. L. H. Bailey, Prof. C. F. Wheeler and Messrs. L. H. Dewey and D. A. Pelton, of the state agricultural college, have commenced their botanical trip across the state, from Harrisville to Frankfort. They will also select a good place for a state forestry preserve, and make their expedition just as scientific as possible in order to earn the money which the state devotes to the enterprise. There will be no hurry about the trip, and everybody is going to make copious notes upon each day's work.[13]

Specimens collected on the expedition constitute a tangible result of its work. Approximately 300 sheets have been found in the Beal-Darlington Herbarium at Michigan State (MSC) in a complete search of the collections. The Bailey Hortorium at Cornell (BH) loaned over 100 sheets kindly located for us by Dr. Peter Hyypio. Some of the BH sheets bear the numbers of Bailey's List, but many are not on that list. Evidently some specimens were supplied to Bailey from the portion of the trip (Grand Traverse and Benzie counties) after he returned to Lansing from Fife Lake; these are attributed to Beal or Wheeler, but the labels, like the others, are in Bailey's hand. Locality data are sometimes suspect on these later collections; e.g., several are attributed to Wheeler or Beal with date of June 21, 1888, and the only locality "Gd. Traverse Co." but these are undoubtedly duplicates of MSC collections which they closely resemble of the same date from Inland Township, Benzie County (see note 89).

Several collections have been seen in the Gray Herbarium of Harvard University (GH), but no systematic search has been made there except for gymnosperms and monocots (in connection with *Michigan Flora* mapping). The majority of these are ex herb. C. F. Wheeler, especially Carices which were bought in 1910. Some others are labeled by Bailey and are ex herb. Walter Deane (1848-1933), a charter member and long active in the New England Botanical Club and a long-time friend of Bailey's.[14] Occasional specimens have been seen in other herbaria, including the National Arboretum (NA), the University of Illinois (ILL), and Cranbrook Institute of Science (BLH).[15]

Probably a few specimens have been overlooked in MSC and BH, and additional ones will surely turn up in other herbaria. We hope that our report will help in clarifying labels, for the specimens are often labeled very cryptically. Even if the correct county is indicated, a locality like "Block House" or "Potts Farm" means little today. And most serious of all, the labels have an unusually high incidence of errors and contradictions. Sometimes the date and the locality are mutually contradictory, given the known route and schedule, and it is necessary to decide which of the two should be accepted. Sometimes the wrong month, "July," is written, an obvious lapsus. Labels of apparent duplicates may

[13]Notes 40, 47, and 95 quote the only additional items concerning the expedition in the *Evening News*. We have not been able to examine the fourth principal Detroit daily of the time, the *Journal*. Notes 22 and 56 quote the only news of the expedition found in the *Crawford Avalanche*, published weekly at Grayling. For quotes from the weekly *Alcona County Review*, published at Harrisville, see notes 22 and 47; the *Review* on June 22 reprinted the dispatch from Mio carried by the Detroit *Tribune* on June 16. Strangely enough, we have found no mention of the expedition in available Lansing papers.

[14]See Rhodora 33: 75 (1933) and 75: 497 (1973).

[15]The only figure we have seen of total specimens collected is the 1,400 given by the Detroit *Evening News* (note 47); if this figure is reliable, and not an error for 400 (see note 17), less than a third of the collections seem to be extant.

disagree as to the exact locality. One sheet of *Carex vaginata* in MSC is labeled "Near Mio" and another, "Comins"; one in GH is labeled "Mio" in Bailey's hand and Bailey's List says "Mio"; all say June 14, when the party had dinner at Comins Farm and arrived at Mio later. Were there two collections made in Oscoda County June 14, or are these duplicates? One sheet of *Equisetum pratense* in MSC is labeled "Sand dunes, Frankfort" June 22; another, "Sand dune on L. Michigan shore north of Frankfort" June 22; yet another, "Sand dunes Frankfort" June 23. The latter is labeled in Wheeler's hand although no collector is stated, and is the only collection found dated June 23. Almost certainly these three collections were in fact made at the same time and place.

A few specimens are labeled in the hand of Wheeler and fewer still in Beal's nearly illegible hand.[16] Some, as already indicated, are in Bailey's hand. Almost all the rest are in an unknown hand (Fig. 2), apparently neither Dewey's nor Pelton's, although both students stayed in Lansing after their graduation. Evidently the late Dr. H. T. Darlington, curator of the herbarium at Michigan State 1914-1945, tried to identify the unknown writing, for a note in Darlington's hand on a sheet of *Similax* collected in Benzie County June 21, 1888, reads: "The label this is replacing has been sent to L. H. Dewey for identification of hand writing." So far as we know, the writing was not identified (and the original label never restored). Dates and counties on these labels are frequently crossed out and written over, names are often misspelled or inconsistently spelled, abbreviations are inconsistent, and in general the labels give the impression of having been prepared hastily, or from inadequate data, and without all duplicates or even all collections from the same site being together for consistent labeling at one time. *Botrychium lunaria* collected June 12 is labeled as "1-12-88" and the initials "J. W. B." are given, presumably for W. J. Beal. One wonders if the labels were prepared by someone unfamiliar with the expedition or even with its personnel.[17] Some labels have "By." added and these generally are species on the Bailey List, although sometimes the wrong number seems to have been assigned. Collectors are only rarely indicated on the labels, although a very few do mention "Forestry Com. Exped." or "Botanical Expedition."

Altogether, the history and labeling of the specimens is a mystery. Those in GH and BH seem largely to have come from the private herbaria of Wheeler and Bailey, respectively, and yet these are often not duplicated in MSC. As

[16]Even labels in Wheeler's own hand have slips, as the *Equisetum* cited above and *Potentilla tridentata,* attributed to the Block House July 14, 1888, rather than June 14; and *Vaccinium brittonii* (BH) is labeled by Beal as collected at the Block House July 16, 1888.

[17]Beal (1890, p. 46), in his herbarium report for 1888-1889, wrote: "About four hundred specimens collected by the botanical expedition across the State in June of 1888 were added to the general collection." He also stated (p. 49): "I am under obligation to my assistant, L. H. Dewey, for much work done in improving the herbarium . . ." Possibly Dewey was responsible for having someone write a set of labels—and later added the initials of himself or his classmate, D. A. Pelton, for certain collections. Several labels have initials such as L.H.D. or D.A.P. added. On the other hand, appearance of data in Beal & Wheeler (1892) and Beal (1905) based evidently on Bailey's List (which was sent in 1890 according to Wheeler's notation on it), and not on the labels of MSC specimens (see contradiction, e.g., for *Carex schweinitzii*, note 50), suggests that the specimens were not available—or at least not consulted—in the herbarium as early as the 1888-1889 accession mentioned by Beal.

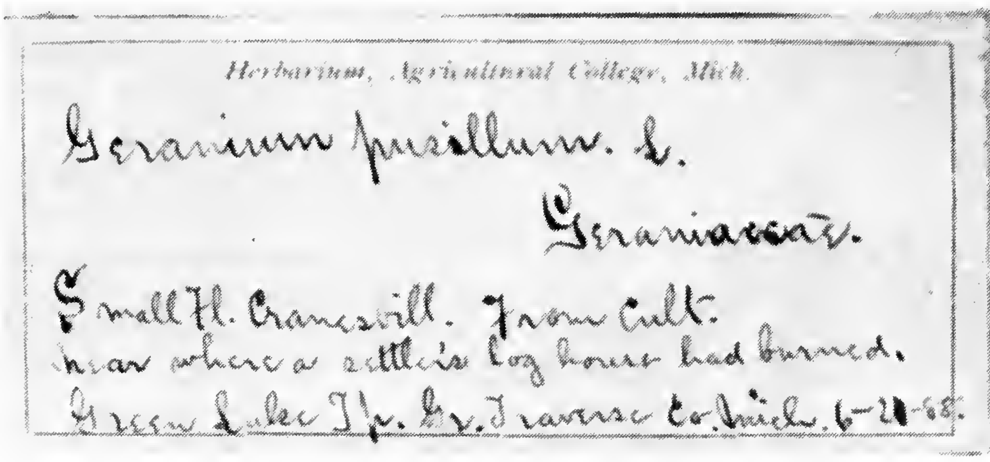

Fig. 2. A representative label, in the unknown hand by which most labels from the expedition were written in the herbarium of Michigan State University (MSC). See note 87 for listing of this collection.

noted earlier, some collections were sent by Bailey to Watson at GH for determination. We have not tried in the lists for various localities to call attention to all the minor inconsistencies and problems regarding labels, but offer our best judgment. In general, we make no distinction between localities modified by "Near" and those not so modified, for often it is apparent that, e.g., "Near Mio" and "Mio" were used interchangeably. Many of Bailey's labels are a standard form on which "Near Lansing" is printed, the "Lansing" being crossed out and replaced by another locality. On the other hand, in the backwoods of 1888, "near" may well have been a relative term, and one was "near" a settlement whenever he was some miles closer to it than to another. When a specimen is labeled "Near Frazer's," a locality two miles into eastern Crawford County, is it possible that the collection was made in Oscoda County, over two miles to the east (see note 50)? We will, of course, never know for certain, but we have been inclined to associate "near" localities with the locality itself in the absence of any evidence to the contrary (including habitat possibilities as determined from our own retracing of the route in the field). Collecting in a bog east of Fife Lake, in Kalkaska County, for example, was terminated by the approach of a severe storm and the party arrived "wet but happy" just across the county line, in Fife Lake, Grand Traverse County, for the night of June 19. We assume, therefore, that bog plants collected at or near "Fife Lake" June 19 came from Kalkaska County (see note 79).

We have included in footnotes on the *Free Press* articles, which follow, clarifications of route and of localities, partly to aid in documenting collections made and partly to emphasize the newness of settlement in the area visited. In providing selected historical data, we hope to convey some of the flavor of the times and the pioneering nature of the expedition. We also provide lists of extant collections which we have located for the various sites, and some references to published reports not verified by specimens. The notes on localities and collections should be of help to anyone trying to plot distributions from the old labels or to interpret additional specimens which may yet be found in herbaria.

ACKNOWLEDGMENTS

We express our gratitude to the large number of individuals and institutions who have helped in the detective work which reconstruction of this expedition has involved. Some are cited in footnotes. We are especially indebted to the Michigan State University Archives and Historical Collections and the Michigan Historical Collections/Bentley Historical Library of The University of Michigan.

Dr. Peter A. Hyypio generously searched for specimens in the Bailey Hortorium. Miss Ethel Z. Bailey expressed her interest, but was able to provide no additional information, writing: "Father often talked of Dr. Beal and Charlie Garfield and sometimes of Prof. Wheeler, but I do not recall any stories about this expedition." Walter Judd searched in the Gray Herbarium for certain collections. We appreciated the sharp eyes of Robert Marquis in the field, and his helpful advice.

We are under special obligations to several persons interested in local history, who were immensely helpful in correspondence and almost all of whom we were able to visit personally in the course of our 1975 expedition: retired judge Herman Dehnke of Harrisville and Mr. and Mrs. Gordon McGregor of the *Alcona County Review*; the late magistrate Charles D. Hager of Mio; Allen C. Nash of the Au Sable River Valley Historical Society, Mio; Earl G. Steiner, Pioneer & Lumbering Museum, Fairview; Dr. Hazen L. Miller, now of Petoskey and the North Branch of the Au Sable; Fred C. Hirzel, of Moorestown, Missaukee County, whose concern for preserving the lumbering history of northwestern Michigan has been a special inspiration to the senior author since a first visit with him in 1954; Mr. and Mrs. Lynn Rayle of the Grand Traverse Historical Society, Traverse City.

Finally, we and our readers owe special thanks to the Department of Botany and Plant Pathology of Michigan State University for aid in providing funds to make possible the publication of this report in full.

[June 13, 1888, p. 4]

A SCIENTIFIC EXPEDITION.

A Party from the Agricultural College on a Tour of Exploration.

HARRISVILLE, MICH., June 12.—[Special.]—Of course, it is necessary to introduce the party. It is also necessary to say something regarding the party referred to and their mission up here in the north woods. First should be mentioned Dr. W. J. Beal, Professor of Botany and Forestry of the State Agricultural College at Lansing. Dr. Beal is about 50 years of age, with a stubbly gray beard, sharp, restless eyes, and a fine intellectual face. He is a gentleman of note in scientific circles, both in and out of Michigan. His whole mind just at present runs to trees, shrubs, plants and grasses. He oozes botany, forestry, flora and climatic influences at every pore. The sight of a new or unusual variety of anything green is sufficient to plunge him to the neck in the deepest morass, or start him on a lively scramble into the depths of the most impenetrable forest. He is wedded to his science, and his science is doing so well that she seems to have no desire to apply for a divorce. He can call the whole State of Michigan by its Latin name without once getting mixed in verbs or tenses. He is one of the few, much-to-be-envied men who can see—

"Sermons in stones and books in running brooks."

Dr. Beal is one of the two directors appointed by the State Board of Agriculture to investigate the Northern portion of the Lower Peninsula in the interests of forestry and botany. The other director is the Hon. C. W. Garfield [see note 10], of Grand Rapids, but poor health prevents him from participating in the present expedition.

The second of the party is Prof. L. H. Bailey, Professor of Horticulture at the Agricultural College. He is a shrewd, scientific man, about 40 years of age.[18] He is also a devout worshiper of his profession and positively revels in the

[18]Bailey had actually just turned 30 three months earlier, and an abridgment of this paragraph was thus corrected when quoted by Kuhn (1948). Beal, described as "about 50"

opportunities for investigation and scientific research presented by his present surroundings. He is out of bed at the most unearthly morning hours, splashing about in the dew and malaria, bending with his intellectual head very close to the earth and gloating over the new and the mysterious in nature. He comes back to camp with his brain teeming with newly acquired information, and—a most ravenous appetite.

Then there is Prof. Charles F. Wheeler, of Hubbardston. His hobby is flora. He knows as much about all sorts of blossoms and plants as does any man in the entire country. He has studied so hard over it that he has grown very thin—a fact which adds materially to his intellectual appearance.[19] He has traveled many times over Michigan, looking for flowers, and—found 'em every time. In 1881 he—with Irwin [sic] F. Smith—furnished "The Flora of Michigan" for the State horticultural report. It is said to have been the best and most thorough work of the kind ever accomplished. He is a good "field botanist," and his fielding ability renders his assistance invaluable on the present expedition. He wears a long, flowing, Buffalo Bill goatee, and looks exceedingly picturesque as he flits about over the unbroken face of nature fighting ravenous mosquitoes with one hand and gathering rare specimens with the other.[20]

Messrs. L. H. Dewey and D. A. Pelton, members of the senior class at the college, who are especially interested in the study of botany, are also of the party. They are both young, slender and pale, and full of scientific enthusiasm. They are armed with curious-looking and very large tin boxes for the reception of specimens, and presses for properly preserving them. They are new to the roughing it features of life, but are enduring the trying ordeal like scientific heroes.[21]

These five gentlemen constitute the strictly scientific members of the expedition. Two Detroit reporters, W. W. Metcalf, of Grayling, Deputy Sheriff of Crawford County, who officiates as teamster and general stage manager of the party, an excellent team of horses, a white covered wagon of the "prairie

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had, on the other hand, just passed 55. The *Tribune* reporter described the two: "Prof. Beal, who directs the affair, . . . is a man of medium hight, full-faced, with a white beard and somewhat denuded head. He wears a straw hat, calico shirt and his oldest pair of trousers. His abilities are well known. Prof. Bailey is considerably younger. He has the face of a student, and wears very mild sideburns. He enjoys camping out, has been through the Northwest [i.e., Minnesota!] among the Indians and knows how to make excellent coffee. He is also an amateur photographer . . . . He dresses like his colleague."

[19]Despite the appeal of the reporter's explanation of Wheeler's spare frame, the truth is that he "never fully recovered from the effects of service in the army" from which he received a medical discharge in 1863 (Wight, 1910). It was in hopes of regaining his health that he moved to Michigan and took an interest in botany.

[20]The *Tribune* reporter, likewise impressed, wrote: "The Botanist Wheeler wears a long goatee, a silk traveling cap and his oldest clothes. His abilities to wade through morasses, climb hills and secure the most interesting specimens are unequaled in the state." Wheeler was 46 at the time.

[21]The *Tribune* referred to these "especially bright seniors from the college" who dressed "in the prevailing old clothes fashion and enjoy everything." Guide Metcalf "has the good, honest, rough appearance of the north woods about him and knows every step of the way."

schooner" variety, a tent, boxes of provisions, bundles of blankets and various other necessary commodities for wilderness life, complete the outfit.[22]

The journey northward by rail on Monday was comparatively uneventful, although wholly delightful. The point of disembarkment was West Harrisville, Alcona Co. Previous to reaching this Mecca, the various professors of the party grew loquacious and pointed out the new and the old in forestry by the way with much eloquence. To the man who had never before heard of "Jack Pine Plains," the cause and effect of forest fires, the black wart which destroys the vitality of the red cherry, the canoe birch and its wonderful possibilities, the use and abuse of charred pine logs, the reason why grasses will not flourish in clear sand—and scores of additional scientific problems—the journey was one continuous revelation.

Arrived at West Harrisville,[23] the course of empire took a new turn. The station is seven good long, Northern Michigan miles from Harrisville proper, a town of about 900 inhabitants and the county seat of Alcona County.[24]

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[22]The *Alcona County Review* for June 15, 1888, commenced a short story by saying: "Prof. Beal of the Agricultural Col., and a party of five gentlemen, including representatives of the Detroit Tribune, Free Press, Journal and News, stopped over in Harrisville Monday night." We have no other evidence of additional reporters on the trip, nor any evidence in support of the *Review's* statement: "Herb Bailey, of LaBoeuff's livery stable will accompany the party as far as Gaylord . . ." The assertion that the "objective point on the first stage of their journey is Gaylord, the county seat of Otsego county" is likewise without foundation. There is no evidence that the party ever planned to go to Gaylord, and indeed a *Review* story the next week said "The professors are anxious to get to Grayling . . ." LaBoeuff's livery did provide stage connections with all trains at West Harrisville; but the *Free Press* report of heads bumping on the ribs of the canvas top of the "prairie schooner" and the occasional losing of the way by the driver make clear that the party did not take the local stage at all. (See also driver Metcalf's complaint in note 56).

The *Crawford Avalanche* (Grayling) for June 14, 1888, noted: "W. W. Metcalf with his team left for Harrisville last Saturday morning to join the Botanical expedition of Prof. Beal, of the Agricultural Department." The *Avalanche* for June 21 carried a brief report: "Our town was honored over Sunday by the presence of Prof's. Beal and Bailey of the Agricultural College, W. C. [sic] Wheeler a noted botanist, of Hubbardston, Herbert Parrish, representing the Detroit *Tribune* and Messrs. Pelton and Dewey, students of the college, who are crossing the state on an exploring and botanizing expedition. They are driven by W. W. Metcalf, of this place who brought them from Harrisville and will take them across the state west via Walton."

[23]West Harrisville was settled in 1885, platted in 1886, and given a post office in 1887. The name was changed to Lincoln in 1899, and the village was incorporated in 1907. The *Tribune* reporter stated that the railroad "formerly went through Harrisville itself, but it is said that the inhabitants placed too great a taxation on the road's property and compelled the withdrawal. The place appears to be doomed on that account . . ." Actually, the railroad did not go through Harrisville until just after the turn of the century, after the Detroit & Mackinac Railway Co. took over the Detroit, Bay City & Alpena Railroad. For a while, lines were continued to Lincoln as well. Rail service to any place in Alcona County had begun scarcely two years before the 1888 expedition.

[24]The site of Harrisville was settled in 1854 and soon afterwards was named for Benjamin Harris and his sons, who developed the village, "a mere notch cut into" the cedar swamps that bordered the shore of Lake Huron (Powers, 1912, pp. 501-502). The Harrisses left in 1866 but the name persisted and the village was incorporated in 1887. Early interest in agriculture is indicated by the founding of the Alcona Agricultural Society in 1872; its 14th annual fair was held in September 1888.

West Harrisville is a mere station, surrounded by a half dozen or so houses of the rudest and most primitive description. On the platform a group, the personnel of which would have delighted a seeker after the good, the pure, and the beautiful, stood awaiting the arrival of the train. They were backwoodsmen of the most typical description and eyed the disembarking party of scientists with mingled expressions of awe, amusement and alarm.

"That's quare lookin' fishin' tackle," remarked a burly young giant whose forest pantaloons were upholstered in six distinct varieties of brocaded jeans, as one of the students sidled upon the platform fondly hugging his big tin specimen box.

"Spects to kick the bucket out here in the woods and fetched his coffin along," suggested another.

"Holy Moses! jest look at the old un," chuckled a third, as Dr. Beal bustled by with odd shapes and sizes of bundles hanging from every available portion of his anatomy. "That chap's goin' ter start a new lumber camp."

The traps were no sooner deposited safely upon the platform than a hasty glance around revealed the alarming fact that Dr. Beal and the two professors had disappeared. It was fully sundown, the mosquitoes were holding high carnival about the railroad track in a systematic effort to bodily carry away a dozen carloads of pine logs, and those seven long miles to Harrisville were still one of the unexplored mysteries of the future. Just as dusk was changing to darkness, the three missing scientists suddenly reappeared on the bank of the little lake. They were visibly excited. Their heads were bunched over a clump of something green which Prof. Wheeler held with a close death grip.

"I tell you I cannot be mistaken," Prof. Wheeler was saying, as the trio moved slowly toward the station. "This is a magnificent discovery. The very first thing upon arrival, too."

"Are you sure?" Dr. Beal inquired, anxiously.

"Dead sure."

"And this is a new variety of sedge?"

"Wholly new to Michigan."

"I guess you're right. I see the differences now, when I examine it more closely. Well, this is luck."

"This alone is worth all the trouble of coming up here."

"Indeed it is. We---- Hello! We are forgetting ourselves. Here are the rest of our boys waiting to go to Harrisville, and it is growing dark. Here is our driver with his team."

"The white-covered, queer-looking vehicle drew up in front of the station and the boxes and bundles were piled inside. The passengers followed, bumping their heads with monotonous regularity against the rough ribs of the canvas top, and the journey to Harrisville was begun.[25]

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[25]The *Tribune* account allows for no collecting interval upon arrival at West Harrisville, the opening paragraph of the first dispatch, likewise dated Harrisville June 12, being as follows:

"On the depot platform in West Harrisville last evening stood a party of farmers from the neighborhood who had come down to see the train pass. They were somewhat surprised when a company of grave-looking gentlemen, who carried under their arms the long tin cans

Seated on boxes and bales and bouncing violently into the air with the fierce jolting occasioned by the corduroy road the professors continued the "sedge talk" which had so engrossed them at the station. After twice losing his way in the forest the driver landed the party at the Alcona House[26] in Harrisville shortly after 9 o'clock, hungry enough to eat the buckles off their gripsacks. The landlady was surprised over the sudden influx of visitors, but was willing to sacrifice her early to bed and early to rise resolutions for the sake of charity—and shekels.

Seated about a cheerful wood fire after supper Dr. Beal proceeded to divulge the following historical and other facts relating to the expedition and why it was undertaken:

"You doubtless know that the last Legislature undertook to pass a law which would encourage tree planting and forestry, and also have something to say on the subject of preventing the forest fires which have been so destructive in Michigan in the past," he said. "This movement was originated by the Hon. N. A. Beecher, of Genesee, a large fruit grower. He did not quite know what he wanted, but was positive that he wanted something. He consulted several of us on the subject and the agitation finally resulted in the present law, which makes the State Board of Agriculture an independent forestry commission. To further encourage the movement the Legislature voted $1,000 to start the ball rolling. The purport of the law also contemplated a list of questions to be answered by each of the 1,200 Michigan supervisors.[27] These questions related to the feasibility of the forestry industry in their respective portions of the country. The subject of the best means to be adopted in preventing forest fires was also embodied. Questions were also sent to fifty additional names in various portions of the State. A forestry convention was held at Grand Rapids last winter to start the movement and it was well attended.

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peculiar to botanists, together with various plant presses and other baggage, alighted, and, entering the wagon ready for them, drove away toward Harrisville proper, seven miles distant on the Lake Huron shore."

The only specimen encountered dated June 11 is *Sarracenia purpurea,* the label reading "Harrisville." Either this was collected in Harrisville upon arrival after dark, or the label should read "West Harrisville," or (most likely) the date is an error for June 12.

What was the "new variety of sedge" discovered, according to the *Free Press,* so quickly in West Harrisville? The party camped at West Harrisville the night of June 12, and all extant collections from that locality are dated June 12 or 13 and thus would presumably have been made after the newspaper dispatch was mailed from Harrisville June 12. Bailey's No. 3 (BH), labeled June 13, was originally called by him "Carex varia var. insolita n. var." but this name was not published and he annotated the sheet as *C. communis* var. *wheeleri,* a name he published the next year (1889, p. 41) with Alcona County among the cited localities (the type later designated from Ionia County by Mackenzie, N. A. Fl. 18: 194. 1935). Was the reporter prophetic, or are the specimens misdated, or was no material saved of the June 11 discovery and more gathered before leaving the West Harrisville campsite on the morning of June 13? The latter seems most likely.

[26]The Alcona House, of which Mrs. Elizabeth Carle was proprietor, is confirmed by the *Tribune* as the place of lodging. Another hotel in Harrisville was the Nevin House, operated by James Nevin, but specimens labeled "Nevin House" are probably from Mud Lake (see note 38).

[27]See Beal & Garfield (1888, pp. 53-68) for the questions sent to the 1185 township supervisors and summary of the responses on amount of timber, damage by fires, and need for legislation.

"The Forestry Commission is expected to report to the Governor two months before the meeting of the next Legislature, and to give such other suggestions regarding the matter as may be deemed necessary. The present expedition is undertaken for the purpose of thoroughly investigating the matter in the northern portion of the Lower Peninsula.

"Then there is another feature of the enterprise which should not be overlooked. A little over a year ago Congress was deeply agitated over what is known as the Hatch bill. Hatch was from Missouri. The bill was agitated for several years and finally passed. By its terms $15,000 per year was appropriated for the use of the Agricultural College in every State and Territory where such institutions had been established. Each State was expected to spend the money in experimenting in accordance with its climate and other natural advantages. Half of the expenses of the present trip will be paid from the appropriation and the remainder by the Forestry Commission already described.

"Another important movement which we are about to set on foot, is the establishment of what will be known as a forestry reserve. This was suggested by Mr. Garfield, and has met with much popular favor. The idea is to set aside four townships where the forests will be carefully protected and allowed to grow up and mature in the natural way. They will also be carefully guarded from the inroads of forest fires. All sorts of game will be provided and allowed to roam these forests unmolested. In short, we shall endeavor to convert this forestry reserve into one great natural State park. The idea has completely captured the sportsmen in all portions of the State, and they are very enthusiastic over it.

"Now I will tell you something in regard to the five experimental stations which we have already established and by that time I think you will have a pretty thorough understanding of the purposes of the present expedition. All of the five stations were opened in April last. One is at Oscoda, Iosco Co., where ten acres of jack pine land were donated by James Barlow. Five acres of this tract were broken this spring. In little patches of about a quarter of an acre each we have sown eighteen varieties of grasses. Among these varieties are tall oat grass, orchard grass, fowl meadow grass, timothy, perennial rye grass, Italian rye grass, meadow fescue, meadow fox tail, Bermuda grass, red top, common red clover, mammoth clover, Lucerne, millet, Hungarian grass, spurry, spring rye, field peas, sweet clover and alsike clover. Some of these little plats are mixed with several varieties of seeds to ascertain which is likely to thrive the best. The land in some instances was well rolled, in others simply harrowed, and in still other instances the seed was sown upon the ground in an unbroken state. The latter idea was suggested by the fact that seeds often grow and thrive when they are accidentally dropped by the wayside.

"At Walton, Grand Traverse Co., and Baldwin, Lake Co., stations have been established on rented ground and treated practically as the one at Oscoda which I have just described. I had the honor of opening all the stations except the central one at Grayling, which was in part looked after by Prof. R. C. Kedzie. At Harrison, Clare Co., ten acres of land was donated by Wilson & Co. This tract corners on the fair grounds, and is but half a mile from the town. Here we have seeded five acres of adjoining rented land that has been under cultivation, and will get ready to go to work on our own next fall. It is hard to say yet just what treatment will finally be decided upon. These experiments must determine that.

"At Grayling, Crawford Co., is what we call the central station. Here the Michigan Central Railroad Company donated eighty acres of unimproved land about half a mile from the town and cornering on the railroad track.[28] Twenty acres of this have already been broken and seeded or planted this spring. Twenty acres additional will be broken by July 1. This is all nicely fenced with boards and cedar posts. As fertilizers we use marl, made of soft shells from a small lake near by, plasters for the clovers and cheap commercial salt. I look after the grasses and other forage plants, putting them in small plats about a rod square. I have already put in about seventy-five varieties at the Grayling station and am ordering others. About fifteen years ago I brought large quantities of seeds from the Kew Gardens in London, England. These I have ever since cultivated in plats at the college. Some of the seeds now used were sent us from the United States Agricultural Department. I am now ordering seeds from Montana, Colorado, Utah–wild grasses–Texas and Northern Russia. I order altogether through skilled botanists. I am also writing, through the government, to the Ministers of foreign countries. Among these I may mention the cooler portions of Japan where I will be assisted by three resident graduates of the college–Northern China, Siberia, Mongolia, Kamschatka and Patagonia.

"At Grayling we have planted about 6,500 trees, of seventy-one varieties. These are northern forest trees. We use nothing save hardy varieties. Thirty-one of the varieties originally came from Russia. We plant them in rows four feet apart on newly broken ground. We will cultivate just as if they were corn. Others are set in on jack pine land that has been simply harrowed over. A few we plant on wholly unbroken land. We expect by next spring to do some experimenting in the line of fruit trees. We may decide to breed them up there. The plan of having these improvements made has met with almost universal approval. Perry Hannah, of Traverse City, being about the only man to declare them impracticable and useless."[29]

The plans for the scientific expedition embody an elaborate programme. Tuesday will be spent in botanizing along the lake shore about Harrisville, after

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[28]See note 57. For a report on the experimental farm at Grayling (including data on soil and sunshine temperatures, experiments, etc.), see Rep. St. Board Agr. Mich. 28: 78-105; 160-163 (1890).

[29]The *Tribune* also indicated a special aim "to investigate the pine barren lands, or pine plains, or 'jack pine districts' as they are called, and see what can be done toward making those barren, useless districts fertile." Beal is quoted as saying "Perry Hannah of Traverse City is the only man in the state I have heard say it can't be done." Mr. Hannah had attended the forestry convention at Grand Rapids in January, 1888, and "said the hard wood of northern Michigan was worth more than all the pine the State had ever produced" (Beal & Garfield, 1888, p. 12). Timber was the principal interest in which Hannah was involved. In 1851, Hannah, Lay & Company of Chicago purchased the site of Traverse City from Capt. Harry Boardman, whose son had established a sawmill there. Perry Hannah (1824-1904) was a state representative in 1857, the first president of the village of Traverse City when it was incorporated in 1881, and generally a business and community leader. In the 1880's, Hannah and Lay's Mercantile Company, the largest in the state outside of Detroit, advertised themselves simply as "Dealers in Everything." (See also Barnes, 1959, pp. 2-5; 23-30.)

which several days will be spent in a zigzag wagon journey through the wilderness, where human dwellings are a novelty and wild animals curious and of an investigating turn of mind, to the western shore. The journey will be slow, frequent halts being made for purposes of scientific research. Among other things investigated will be several beaver dams. A bountiful supply of large, auburn-haired and fiery-breathed musquitos have also signified their intention of accompanying the party for the purpose of absorbing scientific knowledge by the way of the alimentary canal. Wild, weird rumors of the bear and wolf industry being still secreted by the wayside in several of the counties to be traversed add a spice of adventure to the prospect, while more agreeable narratives of the haunts of the festive grayling serve to relieve the monotony.

[June 14, 1888, page 7]

A DAIRYMAN'S PARADISE.

What the Scientists Think Alcona County will Become.

WEST HARRISVILLE, June 13.—[Special.]—The scientific expedition is still doing as well as could reasonably be expected. The professors and students from the Agricultural College are enjoying a regular picnic among the pine trees, the widely varying smaller vegetation and the vast pine plains. They scarcely take time to eat, sleep or drink. Yesterday morning the sun had not yet thought of turning over on his other side and winking the world into a state of semi-consciousness when five stealthy figures, armed with long tin boxes, an intellectual smile and an air of fierce scientific determination stole out of the primitive little hotel at Harrisville and spread gradually over the smiling face of nature on the shore of Lake Huron. They were after something. The shore at this point is low and marshy, consequently admirably suited to the purposes of the five stealthy figures. They positively gloated over the prospect of splashing and floundering about among hidden pools, green slime, mellifluous bullfrogs and ambitious mosquitos. Botanical specimens flourish with more lavish profusion in spots where the ruthless hand of man finds it most difficult to grasp and defile them.

All through the early hours of the morning, the splashing and floundering process was continued with monotonous regularity. Ever and anon the low, musical kerchunk of a slender, scientific form as it plunged up to the neck in black, chilly looking slime, in a futile endeavor to secure an inaccessible specimen, fell upon the pure morning atmosphere with rhythmical cadence. Startled frogs gave quick, horrified glances over the tin-box equipped group, armed with long, murderous appearing knives, then vanished beneath the cold, dark green scum of oblivion. But every step of the foraging expedition was made to pay. The enthusiastic spectacle of a professor emerging from some hidden recess with one hand grasping a slender, fragile, botanical specimen, the other clinched fiercely around the hilt of a murderously inclined stiletto, his tin-box pulling vigorously on the strings from which it was suspended, and his face mantled with an expression of satisfied triumph, was very numerous during the morning hours. Unusual botanical specimens were exceedingly plentiful on the shore of the lake in Alcona County.

"I am surprised to find many specimens of vegetation in this locality which I had no idea flourished so far north," said Dr. Beal, when a brief respite was taken for breakfast. "We have struck it rich on this trip, and no mistake. Now, down there," pointing with his knife toward the bay from which he had recently emerged dripping green slime, "I found a perfect treasure house of specimens. Now, take the red and white currants, for instance. They grow wild in the swamps of Europe, and I find them plentiful here about Harrisville. They need a rich, loamy soil and will not thrive in sand. Then there are the wild gooseberries. The cultivated varieties are derived from the wild, and the latter are very plentiful in this region. They thrive best in loam. Down there, too, I found the moon fern, or *botrychium lunarioides,* which has not before been discovered in Michigan south of the Upper Peninsula.[30] That alone was worth the trouble of this entire trip. I also found the mountain ash and white birch, both exceptionally good finds. In regard to Alcona County, in a general way, I should say that it will develop into a regular dairyman's paradise. The grasses of all sorts will flourish well here and cool streams of the purest water—as you have seen—trickle over the hills and bluffs at frequent intervals. We are compiling a careful list of the flora as we go along. You have doubtless noticed the difference in the advancement of vegetation here from the progress made in the southern part of the State. Three weeks ago the difference did not seem to exceed three or four days between this point and Lansing, while now the common lilac here are just in bloom. The same is true of the hardy varieties of cherries. Now, everything here is at least two weeks behind Lansing. The reason probably is to be found in the fact that the weather came off suddenly warm in the lower counties."

The day was spent in investigating the shores of the lake for a distance of about five miles north of Harrisville, at which point is located Sturgeon Point Life Saving Station, under charge of Capt. James E. Henderson and eight assistants.[31] This is one of the most important stations on the entire coast and is in very capable hands. Capt. Henderson conducted his scientific visitors carefully over the premises, explaining in minute detail the workings of the service which was created for the benefit of the brave fellows who take their lives in their hands and go down to the sea in ships. Within a stone's throw of the station is

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[30]The *Tribune* likewise called attention to "one fern never before found south of the upper peninsula . . . *botrychium lunaroides* . . . a little weed-like looking object . . ." It was cited (as *B. lunaria*) from Harrisville by Beal (1889, p. 181) and in Beal & Wheeler (1892, no. 1725): "collected in 1888 at Harrisville by Dr. W. J. Beal." The collection has been determined by W. H. Wagner, Jr., as the segregate *B. minganense,* now known from at least 8 counties in the Lower Peninsula, as far south as Wayne County.

[31]The *Tribune* described the trip to Sturgeon Point more fully:

"The plan of the day arranged for a detour to the north along the lake shore for a few miles before the final start West was made, and for a long distance the wagon traveled on a good hard road between the low marl bluffs on one hand and the great blue lake on the other. The day was perfect. The trip was made in true Bohemian fashion. The great prairie schooner which carried the party sailed away at a lively rate, but the instant the keen eyes of the botanists detected anything which they had not yet obtained, the cry of 'man overboard' was given, and anchor was cast until the desired object could be secured. Profs. Beal and Bailey held lengthy discussions over some common-looking weed which a country boy would not have noticed, and the keen eyes of the two students, Dewey and Pelton, seemed to see through fence rails and posts in their active search for new flowers.

"Dinner was eaten at the Sturgeon Point life saving station, and Capt. Henderson and his oaken-hearted crew exhibited and explained the interesting features of their life at the dangerous point . . ."

located the light house, under charge of an aged Frenchman, whose entire life has been spent in one long, vigorous warfare with the demon of the turbulent waters. With his aged wife, he lives out his lonely life on the desolate point, happy in listening to the turbulent song of the waves as they dash day and night against the base of his fortress-like dwelling. The old keeper looked askance at the long tin boxes, plethoric with the treasures of forest and dell.

"The idea of foolin' away good time gatherin' them pesky weeds," he muttered in broken French. "They ain't no good to nobody. Ef you want to lug home suthin' to remind you of this place, why don't you pick up some of these shells here on the beach. There'd be some sort o' sense in that. But them p'ison weeds!" with a contemptuous shrug of the shoulders. "It jest beats all what fools some fellers be!"

And the old keeper ambled up the winding iron stairway with the agility of a squirrel.

The same course of reasoning constantly troubled the mind and disturbed the peace of Teamster Metcalf. He wasn't up to the mysteries of botany and as he sat passively in his wagon and watched his passengers flitting like specters among the trees, or wading in disagreeable slime, his curiosity and contempt were poorly concealed.

"I never saw the best of it," he said. "Why, I can go right out into my dooryard at Grayling and pick bushels of weeds and wild things that knock the spots off of them things that those chaps go crazy over. The idea of spendin' all this time and money jest to gather tin buckets full of common weeds. Ef them was flowers, now, or suthin' else that was wuth while, it might be different. Well, it's no business o' mine, I s'pose, but I do get tired settin' around here in the woods an' watchin' them fellers make fools of theirselves."

"I suppose you notice that apple and cherry blossoms, also the Missouri currant, are now just in their prime at this point," said Dr. Beal. "This is largely owing to the cool lake breezes from the north, and must be considered in estimating the possibilities of this region. For fruit I should say this would be favorable. Vegetation escapes the late frosts by being kept back. South of Harrisville the shores of the lake are too high for peculiar lake shore plants. To the north, however, the banks are low for half a mile toward the interior, and sand is not prominent. Alcona is the only county on the Huron shore where the hardwood timber reaches the edge of the lake. This denotes the presence of sandy loam and clay. Among the plants we find here may be mentioned the beach pea, silver cinquefoil, and shore rush. We are rather disappointed in not finding either the sea rocket or Pitcher's thistle, which we fully expected to do. The latter was named after Zina Pitcher, the late scientific Detroit physician."[32]

"We found the hair sedge, though," broke in Prof. Bailey. "That is the most unexpected and surprising find of all. I have never seen this variety except on Drummond's Island and on the summit of the Rocky Mountains."[33]

[32]*Cakile edentula* and *Cirsium pitcheri* do indeed occur at Sturgeon Point (both collected by R. McVaugh in 1951), even if this expedition rather understandably failed to note them in mid-June. We saw several seedlings of *Cakile* on the beach at Harrisville State Park on June 12, 1975.

[33]*Carex capillaris* was cited by Wheeler & Smith (1881, no. 1392) only from Point de Tour on the authority of Gray's Manual. It is now (Voss, 1972, p. 307) known in the

"We all feel exceedingly well pleased over this day's work," continued Dr. Beal. "We have certainly found a greater number of species than we expected to. I should say that we have found 215 species of flowering plants, ferns and their allies.[34] Then there are many varieties which we are unable to recognize, owing to the fact that they are not yet in blossom. This region of the State has a good future before it—there is no questioning that fact. We also found one wholly unknown species of sedge."

Tuesday night the big tent was pitched in the deep forest which surrounds West Harrisville—the first actual camping experience.[35] In camp work Prof. Bailey is invaluable. He has tramped all over the United States and British America on botanical expeditions, sometimes as a member of scientific parties, sometimes accompanied only by an Indian guide, and sometimes wholly alone. He goes to Cornell University as Professor of Horticulture with the beginning of the next college year.[36] To-day the party will plunge into the wilderness and even comparative civilization will not again be reached for several days.

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state from the mainland in 14 counties, plus Isle Royale, Drummond Island, Beaver Island, Bois Blanc Island, and Mackinac Island—a good example of progress in botanical exploration of Michigan.

[34]Collections seen from Harrisville and vicinity, June 12, are as follows (at least one sheet of those marked with an asterisk is specifically labeled Sturgeon Point): *Acer pensylvanicum, Botrychium minganese, Carex aquatilis**, *C. arctata, C. capillaris** (1), *C. disperma**, *C. flava**, *C. gynocrates**, *C. lasiocarpa, C. leptalea**, *C. leptonervia**, *C. limosa**, *C. rugosperma**, *Clintonia borealis, Cornus canadensis, Eleocharis erythropoda**, *E. smallii, Euphorbia cyparissias**, *Fragaria virginiana** ("Common throughout from Harrisville to Frankfort"), *Juncus balticus**, *Juniperus communis**, *Lathyrus japonicus**, *Lonicera canadensis**, *Menyanthes trifoliata, Mitella nuda, Myrica gale, Polygala paucifolia, Potamogeton gramineus**, *Potentilla anserina**, *Pyrola asarifolia**, *Rhamnus alnifolia**, *Ribes glandulosum**, *R. hirtellum**, *R. lacustre, R. triste**, *Salix bebbiana**, *S. candida, S. glaucophylloides**, *S. lucida, Schizachne purpurascens, Scirpus americanus**, *S. validus, Sorbus americana* ("On L. Huron shore but not in interior"), *Streptopus roseus**, *Tiarella cordifolia, Viola pallens* ("West of Harrisville"). In addition to the four species of *Ribes* listed, Beal (1889, p. 180) also reported *R. cynosbati* and *R. americanum* (as *R. floridum*), all six said to grow "within a few rods of each other" at Harrisville.

[35]Collections from West Harrisville June 12 and 13, presumably at or near the campsite that night, have been seen as follows: *Carex arctata* (5) *C. backii* (8), *C. brunnescens* (7), *C. communis* var. *wheeleri* (3, 6) *C. disperma, C. laxiflora, C. ormostachya* (10, 11, 12), *C. rugosperma* (9), *Dracocephalum parviflorum* (MSC, BH, GH; cited by Beal, 1889, p. 180; presumably not native this far south), *Gaultheria hispidula, Gymnocarpium dryopteris* (labeled Harrisville, but if June 13 date is right, this must be an error for West Harrisville), *Oryzopsis pungens, Polygonatum pubescens, Waldsteinia fragarioides.*

[36]See note 18. The reporter exaggerates Bailey's experience in North America. He was in northern Minnesota for three weeks in the summer of 1886, following which one of the Indians guided him across the International border into Ontario, Canada (see Rodgers, 1949, p. 113; Dorf, 1956, p. 57). The *Tribune* reporter reiterated Bailey's camp accomplishments:

"With true agricultural thrift, it has been decided to go through the country at the least possible expense. Camps will be made every night, in spite of the temptations of occasional taverns, and there are no professional cooks or French waiters in the party either. The camp of last evening was pitched close to West Harrisville. A single tent with pine boughs and blankets formed the bedding. Prof. Bailey, who has had much experience in these matters, makes the coffee, while the rest perform other menial duties. A most picturesque scene to urban eyes was that at the first camp last night. A pile of pine knots blazed at the entrance, and around it sat the enthusiasts re-examining their finds."

[June 16, 1888, page 4]

IN THE PINE WOODS.
A BIG FARM IN THE CENTER OF MILES OF FOREST.
Excellent Timber and Soil—The Driver Talks About Lumber "Dens."

POTTS' FARM, MICH., June 14.—[Special.]—"I have tramped pretty well over the face of this continent," remarked Prof. Bailey, standing up in the rude wagon and bumping his intellectual head violently against the rough ribs of the canvas-covered wagon, "but never before did I see a bit of natural scenery which approached this in a certain kind of solemn grandeur."

"It is unique," replied Mr. Beal, thrusting his silvered head out through a slit in the cover, only to jerk it violently back again as a bloodthirsty gray mosquito about the size of a humming bird perched coquettishly on the bridge of his Roman nose.

"Too unique for me," muttered Student Pelton, from his perch on a cracker box. "I am rather ambitious in my way, but my ambition does not run to squatting down on a big farm right out in the center of miles and miles of the loneliest kind of forest. Mr. Potts may be a genius, but I don't want to rob him of his farm."

"No, he can keep it—for all of me," chimed in Prof. Wheeler, shaking the dirt from the roots of a big branch of yellow violets which he had plunged into a prehistoric swamp to secure a few moments before. "This sort of thing is all well enough for an outing, or a picnic, but when it comes to living here right along—ugh!"

"Bless your soul! Potts don't live here," explained driver and guide Metcalf. "Not much. He lives off somewhere in Canada, I believe. He's rich as Croesus. Owns miles and miles of railroad, and hundreds and thousands of acres of pine lands. Potts' headquarters—lumber headquarters—are several miles from here—off through the woods. This farm was put under cultivation to raise hay and other stuff to keep the camp running. The Pottses are an awful rich lot and one backed by swads of Canadian capital."

The farm under consideration was certainly a decided novelty in its way. It is located on the highest spur of a range of heavily wooded hills in the extreme western portion of Alcona County. The Potts Farm—as it is known all over the Northern part of Michigan—embodies about 140 acres of sandy loam, all of which is under cultivation.[37] One immense field, which covers more than fifty acres, is reserved for a meadow and is a living proof that pine lands will give magnificent returns for grazing and haying purposes. The varieties cultivated here are timothy and clover and the yield is most abundant. The remaining portions of the cultivated land are devoted to oats, beans, mangel wurzel, all sorts and conditions of garden truck, and pasturage. The surface of the farm is a

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[37]Potts Farm was located in the N½NW¼ sec. 2 and NE¼NE¼ sec. 3, T26N, R5E, Alcona County (E. G. Steiner, pers. comm.). Collections made here, where the party camped for the night, on June 13 have been seen as follows: *Carex arctata* [34], *C. houghtoniana* ("3 mi E Potts farm"), *Geranium bicknellii* [33], *Rubus pubescens* [30], *Viola conspersa* [31], *V. pubescens* var. *eriocarpa* [32; see second paragraph above]. In addition, Bailey's List includes *Lysimachia quadrifolia* (35) for Potts Farm. See also note 43 concerning Potts.

Fig. 3. Dan Pelton fixing breakfast at Potts Farm in western Alcona Co., June 14, 1888, showing the tent and covered wagon used by the expedition. L. H. Dewey is standing by the wagon. (Photo by L. H. Bailey; from M.S.U. Archives & Historical Collections.)

never-ending succession of knolls and hillocks and the soil is an excellent quality of sandy loam. The buildings are crude, yet comfortable. The principal one is a log cabin, and it is surrounded by outbuildings fashioned from the same solid material, and a large frame barn. The spot is of special interest as an illustration of what can be done with Michigan pine lands in the way of cultivation. The Agricultural College scientific party, under the command of the venerable and enthusiastic Dr. Beal, reached the Potts farm at sundown on Wednesday and pitched its tent in a large pasture field in the shadow of the almost unbroken forests of pine and hardwood which shut it frowningly in on all sides. [Fig. 3]

Wednesday was a day of varied experiences. Some of them were pleasant—many most emphatically the reverse. It began to rain in torrents before the party left West Harrisville, a condition of affairs which continued with monotonous regularity until almost noon. The road for the entire distance was through dense pine forests, varied at irregular intervals by jack pine plains of the most barren and uninviting description, openings of irregular dimensions formed by vast forest fires, where the ground was piled high with charred and blackened logs, and where charred and blackened trees loomed grimly up into the heavy atmosphere like forbidding monuments of ruin and desolation. At rare stages the monotony was relieved by clumps of living green, where hardwood varieties of timber followed the course of some valley or stream. The road was little more than a bridle path cut through the solid walls of towering trees, and is left to the mercies of nature and the elements. It is nobody's business to look after it—and nobody does it. Frequent halts for the purpose of removing fallen trees were necessary, a fact which rendered progress slow and laborious. Almost the entire width of Alcona County the Alger branch of the Detroit, Bay City & Alpena

Fig. 4. A lumber camp near Mud Lake [Barton City], June 13, 1888. (Photo by L. H. Bailey; from M.S.U. Archives & Historical Collections.)

Railroad winds and dodges about among the extensive lumber camps which are owned and operated by Alger, Smith & Co., of Detroit.

"Alger owns almost everything you see up in this region," exclaimed driver Metcalf. "We will pass millions and millions of feet of pine logs, piled up on skids by the side of his railroad ready to be shipped off somewhere. This lumber railroad of his is built just wherever it happens to be needed. It is crookeder than a ram's horn. When they decide to cut a piece of pine they run the railroad right up to it. Over there, you see, is a mile or two of the road that is being built. That is to log off them big pines over on the section across the ravine. When the timber is all cut off the whole track of this branch will have to be torn up. It is too crooked to be good for anything for traveling purposes."

The halt for dinner was made at a place which is known to local fame by the euphonious name of Mud Lake.[38] It simply denotes a lumber camp, and contains a rough clapboard tavern and a shoe shop. The entertainment for man

[38]This community, called Mud Lake when the post office was established in 1887, took the name of Barton City in 1912. Specimens collected here, where the party stopped at mid-day, have been seen as follows: *Carex aenea* (17,27), *C. castanea* (14), *C. communis* var. *wheeleri* (28), *C. gracillima, C. laxiflora* (25), *C. leptonervia* (16), *C. plantaginea* (20), *Cypripedium acaule, Kalmia angustifolia* ("W. Mud Lake"), *Utricularia intermedia* (with the moss *Drepanocladus aduncus* var. *aduncus*, det. H. Crum), *Viola lanceolata, Viola rostrata.* (Some collections of *Carex castanea* for June 13 are labeled "Mud Lake" and others "Nevin House"; the latter are apparently duplicates and the locality does not refer to the Nevin House in Harrisville [see note 26] but to the hotel operated briefly by A. Nevins in Mud Lake [Polk, 1889]; a David Nevins also had a lumber camp near Mud Lake at the time.) Bailey's List no. 29 is "Viola Mud Lake. June 13" and W. Judd informs us that a sheet of *Viola adunca* in GH, with no locality except Alcona County, bears this number; a sheet of this species in MSC bears no number or locality other than "Jack Pine Plains north of Au Sable, Oscoda Co." but is dated 6-13-88, which would mean Alcona County, so it may be a duplicate.

and beast was of the typical back woods variety, and a big crowd of natives stood about and sized up the party of scientists while the homely meal was in progress. After dinner Prof. Bailey, who is a skillful amateur photographer, unpacked his apparatus and proceeded to "take" the rude surroundings and the natives in several distinct views. The operation almost paralyzed the inhabitants, some of them evidently having never before heard of the art of photography. [Fig. 4]

"Gosh all hemlock! What is that ere feller doin'?" exclaimed a strappling big backwoodsman, backing up against a log outbuilding and cringing before the business end of a camera, which the Professor was training squarely in his direction. "I don't like to have that thing pointed at me. It might go off."

In the afternoon the weather cleared and the atmosphere was cool and bracing. The scenery was magnificent, being almost a constant succession of wooded hills and valleys, abrupt bluffs and swampy bogs.

"These abrupt ascents and declivities are of distinct glacial formation," explained Prof. Wheeler. "Grand, aren't they?"

A short distance west from Mud Lake an Alger camp in full operation was reached.[39] The camp proper was composed of less than a dozen rude cabins, but they were better and more pretentious than the average camp cabins. The interiors were cleanly and neatly whitewashed, and the immediate exterior was more carefully looked after in the way of general cleanliness. Half a dozen women, mostly young and of French origin, about an equal number of babies in arms, two or three times as many children of more mature growth, scores of ugly looking dogs, and a small army of big, strapping, muscular backwoodsmen, formed the visible camp equipment. Great piles of pine logs, ranging in length from sixteen to 100 feet, and in diameter from six inches to four or five feet, were "skidded" along the railroad track for miles, the result of the winter's labor [Fig. 5] Lumber trains, many of them almost a quarter of a mile in length, were constantly leaving camp, bound for a market. It was a busy scene, of a peculiarly distinctive character. The marketing of long timber for masts and spars—and other purposes for which long logs are required—seems to be a decided specialty in this particular locality of the great Alger industry. Norway pines are noticeably abundant in this region, their long slender stems rising to magnificent hights, smooth and shining. [Fig. 6]

[39]Russell A. Alger, originally of Grand Rapids, moved to Detroit in 1865 after distinguished Civil War service, and entered the lumbering business. Alger, Smith & Company, together with the Detroit, Bay City & Alpena Railroad Company, of which Alger was president and general manager (M. S. Smith, vice president and treasurer), were active in the northeastern Lower Peninsula. Alger's name was prominent in newspapers at the time of the botanical expedition, in connection with his campaign for the presidential nomination; on June 25, however, at the prolonged Republican convention which had opened in Chicago June 19, he was defeated in his bid by Benjamin Harrison. Alger had served as governor of Michigan 1885-1886, and was a director of several Detroit corporations. Specimens collected June 13 at "Alger's Camp" or "Alger's First Camp," which was apparently quite near Mud Lake, include *Carex rostrata* [37], *Corydalis sempervirens, Cypripedium acaule* (38), *Equisteum fluviatile* [36], *Poa saltuensis* ("Border of the Jack pine plains West of Alger's camp."). Beal & Wheeler (1892, no. 1515) list *Carex foenea* from "Alger's Camp, Alcona Co."; this refers to *C. aenea* as now understood, but the extant collections are labeled Mud Lake.

Fig. 5. Skidway at Alger's camp, Alcona Co., June 13, 1888. W. J. Beal is standing near the middle, wearing straw hat. (Photo by L. H. Bailey; from M.S.U. Archives & Historical Collections.)

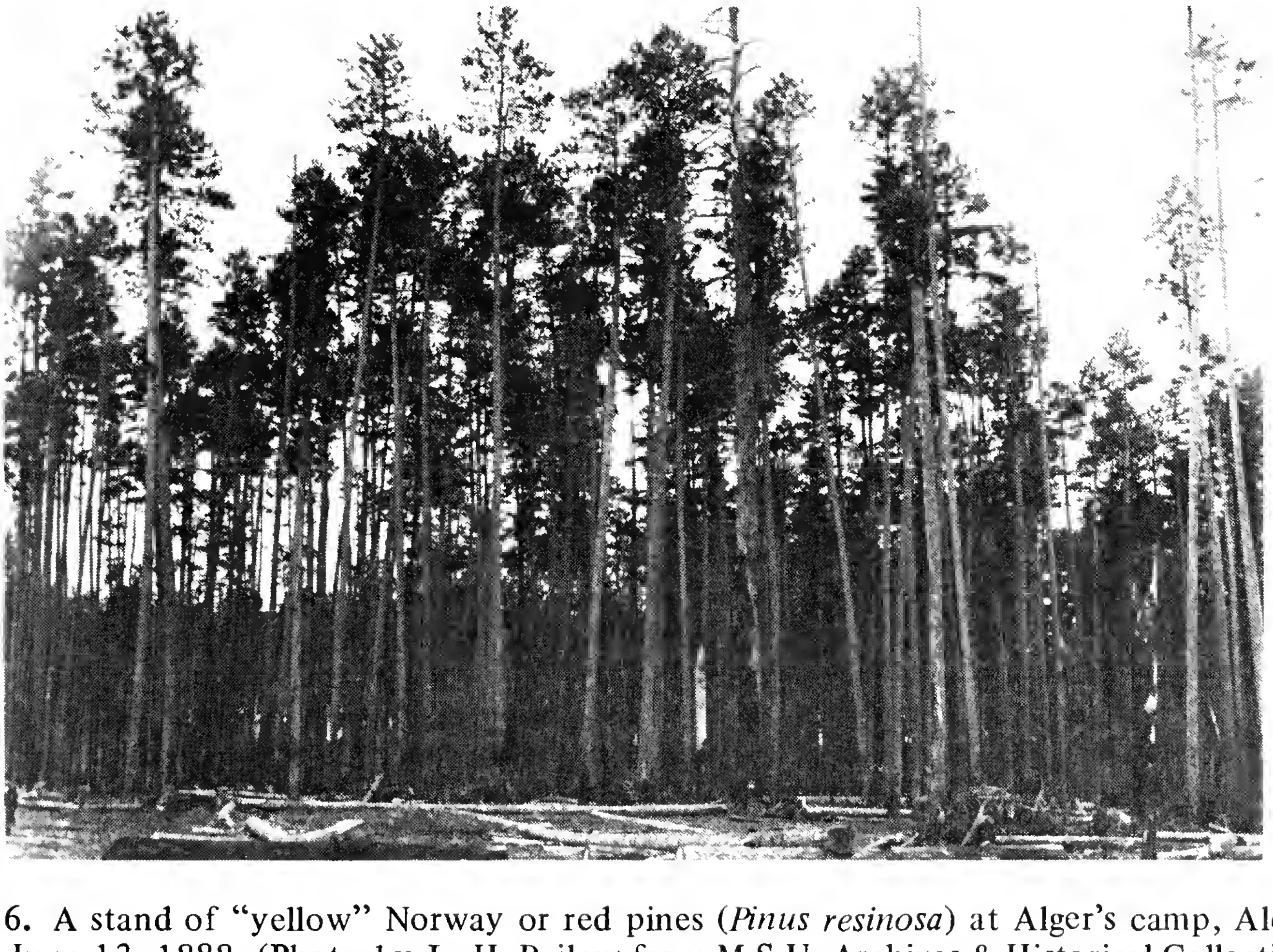

Fig. 6. A stand of "yellow" Norway or red pines (*Pinus resinosa*) at Alger's camp, Alcona Co., June 13, 1888. (Photo by L. H. Bailey; from M.S.U. Archives & Historical Collections. A drawing from this photo appears in Beal & Garfield, 1888, facing p. 35.)

"Do you see that new frame shanty over there in that lonely hollow?" asked Driver Metcalf, pointing away through the trees with his whip. "A few weeks ago that was a house of ill-fame. The inmates, including the keeper, are now lying in the County Jail at Harrisville awaiting trial. I wish somebody would tell me how girls of that class can be content to bury themselves in these awful solitudes."

"Perhaps they are retained as prisoners," was suggested.

"Not much they ain't," was the emphatic reply. "I've been reading the accounts of the Detroit agitation over the so-called stockaded prison dens of the lumber camps, and I tell you there ain't but mighty little truth in the yarns. I've been a land-looker and lumberman all over both peninsulas, and I know just what I am talking about. There may be rare instances where girls are roughly treated—just as such girls are liable to be in any locality—but they come into lumber camps of their own free will and leave whenever they feel like it. As a rule they degrade the men instead of the men degrading them. They are generally the worst of their class, and carry on at a fearful rate at the camps. These girls follow the lumber camps because the boys spend their money freely, and they generally manage to get the most of it. We shall pass another one of these dens out here in the woods to-morrow, and it will be easy enough to verify all that I have said on the subject."[40]

No human habitation, save the lumber camps and a cluster of rude cabins about a shingle mill, was passed during the whole of Wednesday's drive. The vast solitudes were solemnly impressive, and Prof. Bailey succeeded in obtaining several admirable and striking views of typical forest scenes. At one point where the foliage was more dense than any which had previously been passed, the driver pulled up with a sudden jerk.

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[40]The Sunday *Free Press* for June 17 carried not only their reporter's last (and rather short) dispatch from Mio, but also a story headlined "An Oscoda County 'Den.'" This mentions how "a representative of THE FREE PRESS, who accompanied the Agricultural College scientific expedition across Alcona and Oscoda Counties last week" had set out from Mio at 10:00 p.m., accompanied by "Under Sheriff Metcalf, of Crawford County"—the expedition's driver, and the Oscoda County prosecuting attorney, to investigate the "den" near Mio. An editorial two days later called for a thorough investigation, and on June 30 there was finally a follow-up story; however, there was no intimation that the reporter, Mr. Fisher, had anything further to do with the matter. But Fisher evidently left the expedition, since reports after Mio were written by Bailey. Charges and denials about enforced prostitution, particularly in the Upper Peninsula, were much in the Detroit papers at the time, especially in the *Evening News* and the *Tribune.* Under the heading "That Oscoda 'Den'," the *Tribune* on June 25 printed a letter from Ezra L. Smith, prosecuting attorney for Oscoda County, refuting one by one the details of the *Free Press* story and stating more completely that the party which went to the "house in question" consisted of "the TRIBUNE reporter, the Free Press reporter, an Agricultural college student, a Mr. Metcalf and myself." This sidelight of the botanical expedition is not mentioned in any of the reports about it!

The *Evening News* for June 22 reported on "A 'Den' in Alcona" which was "a few rods from the county line . . . almost hidden by a copse of scrub pines." On June 28 that paper reported the incarceration of its proprietor, after examination in Harrisville, and declared that it "was merely a common house, about one-fourth of a mile from the Au Sable river road"; on July 2, the man was reported free on bail. This timing does not accord with the report of persons already jailed when the expedition passed through western Alcona County on June 13, but the location may have been the same.

"There they are," he said, pointing down with his index finger to the water soaked soil. "I thought we should run across them somewhere in this locality. Them's deer tracks. They've been browsing on these tender shrubs by the roadside."

"Our road from West Harrisville," said Prof. Wheeler in the evening, "has been along the watersheds which divide the Au Sable and Thunder Bay Rivers. You have probably noticed that we have not crossed a single stream to-day. In the way of excellent timber and soil this journey is a succession of pleasant surprises. The soil so far is susceptible of the highest cultivation. The species of vegetation found are much more numerous than we had anticipated. White ash, basswood, and red oaks of large size are surprisingly frequent. The west side of Alcona County is rich in all the hardwood varieties, and produces some of the largest and finest pines that I have seen anywhere in the Lower Peninsula. What we have seen to-day in the way of fine timber proves that the establishment of a Forestry Commission was eminently worth while."

The journey as outlined for Thursday will be chiefly over the jack pine plains, a class of scenery which is about the most sandy, barren and monotonous that it is possible to conceive.[41]

[June 17, 1888, page 12]

IN THE GREAT PINE BARRENS.

A Revelation of an Entirely New Order to the Scientists.

MIO, OSCODA CO., MICH., June 15.—[Special.]—Thursday's trip through the jack pine plains of Oscoda County was a reservation [sic] of an entirely new order to the scientists of the Agricultural College. It was the wildness and grandeur of the preceding days all over again—and a good deal more so. The imposing pine forests of Alcona County gave place to miles and miles of bluff and valley, which were covered only with the short, scraggy and bristling jack pine, and shining white and yellow sand. The professors were in an entirely new ecstasy of delight.

"This is what we have been waiting for all along," said Dr. Beal, springing down from the rude wagon and clawing fiercely at the roots of a peculiar botanical specimen indigenous to the locality. "We have now struck the great pine barrens which have heretofore been popularly supposed to be wholly worthless for agricultural, or any other, purposes. If we can prove this supposition unfounded, our journey, arduous as it is, will be eminently worth while. As far as my own opinion is concerned, I firmly believe our experiments will establish the fact that there are certain varieties of grasses and other vegetation that will flourish well in this dry sand, especially if fertilizers are freely used. As it now appears, however, I am free to confess that these pine barrens form about the most gloomy perspective imaginable."

"Speaking of perspectives," said Prof. Bailey, "reminds me that a few views of the more desolate portions of this region would be very interesting to

[41]A number of specimens are labeled Alcona County without further locality. Some are probably duplicates of sheets of the same species with more precise data. Others, not already listed for an Alcona County location, and dated June 13, are *Carex deweyana* ("West Alcona Co.") and *Pinus resinosa.*

Fig. 7. Approaching the valley of the Au Sable, western Alcona Co., June 14, 1888. (Photo by L. H. Bailey; from M.S.U. Archives & Historical Collections.)

those who have never been up this way. Here goes for that ridge over yonder with the charred jack pines sticking up over it like pillars of darkness and evil."

The camera was balanced on a cracker box in the rear of the wagon and a moment later the intellectual head of Prof. Bailey was buried under a rubber blanket and his mild blue eye was squinting eagerly in the direction of the gloomy looking ridge. The operation was repeated as frequently as especially forbidding scenes were reached. [Fig. 7] Meanwhile Dr. Beal, Prof. Wheeler and the two students were carefully inspecting the ground on all sides of the wild path, which the cavalcade was traversing in search of rare specimens of vegetation. Their search was successful at frequent intervals and the queer looking tin boxes were plethoric with scientific fatness.

About 10 o'clock in the forenoon a severe thunder storm, accompanied by a perfect hurricane of wind, which drove the sand in blinding sheets into the faces of the scientists, overtook the party and hurried them into the shelter of the "Block House," a rude backwoods saloon and tavern which stood on the slope of a winding stream in the heart of the wilderness.[42] Here about a score of

[42]The "Block House" was situated on what retains the name of Blockhouse Creek today at the eastern edge of Oscoda County (NE¼NE¼ sec. 12, T26N, R4E), according to E. G. Steiner, who asserts that he knows no one living in the county today who saw it. Operated by a man named Robinson from the early 1870's to the late 1890's, it was a rough place, "a combination saloon, hotel, livery stable, warehouse, and what-have-you" which was "patronized by all classes, saints and sinners of all kinds and occupations, mainly because it was the only place in a wide area where food and shelter could be obtained" (Au Sable, 1974, pp. 56-57). Evidently (Fig. 8), it had just received a new roof when the expedition took shelter there on June 14, 1888. Seven species labeled as collected at "Block House" have been seen: two erroneously labeled June 13, one July 14, and one July 16;

Fig. 8. The "Block House" tavern, eastern edge of Oscoda Co., June 14, 1888. Note the covered wagon and horses just above center of picture. (Photo by L. H. Bailey; from M.S.U. Archives & Historical Collections.)

typical backwoodsmen stood around a rude bar and stared at the scientists and their outfit in a manner which destroyed their comfort and peace of mind most thoroughly during the hour in which they were held as prisoners by the driving storm.

An hour later found the "prairie schooner" passing "Potts' Headquarters," a lumber camp made up of about a dozen cabins, a saw-mill and a rude hotel.[43]

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three are labeled Alcona County, two Oscoda County, and two with no county. We assume that collections were made *after* the storm and hence are all from Oscoda County: *Amelanchier spicata* [56], *Crataegus macrosperma* [55], *Potentilla tridentata, Prunus virginiana* [60], *Rosa acicularis* [57], *Salix humilis* [61], and *Vaccinium brittonii*. All are common species in this jack pine region except possibly the *Crataegus*. We visited the site June 13, 1975, but the only fertile *Crataegus* was *C. chrysocarpa*; small sterile diseased shrubs may have been *C. macrosperma*. (See Fig. 16.)

[43]Potts Headquarters was established about 1884 near the center of sec. 15, T26N, R4E; "Potts" post office began operation in 1886. The J. E. Potts Salt and Lumber Company put 100,000,000 board feet of lumber into the Au Sable in the 1887-1888 season, at which time they had a force of 450 men, 80 teams, and 7 locomotives (Fitzmaurice, 1889, pp. 70 & 103); by the end of 1888 they had 10 locomotives and 160 cars to operate on their 44 miles of railroad (Poor, 1889)! The Potts Co. failed in 1890 and in 1892 the lands and equipment were bought by Henry M. Loud and sons, strong Republicans who changed the name of the town to honor then presidential hopeful William McKinley. Once the largest town in the county, McKinley became a ghost town after 1900, although some resettlement occurred, and the post office closed in 1913. (See Otis, 1948; Au Sable, 1974, pp. 14, 35, 46, 47, 49.)

The expedition apparently did little collecting at Potts Headquarters on June 14, only the following specimens being seen: *Cirsium muticum* ("In White Pine Forest near Potts"), *Potentilla tridentata* ("Abundant on Jack pine plains. Potts"), *Salix pedicellaris, Trillium grandiflorum* ("Jack Pine Plains. Near Potts"). Beal & Wheeler (1892, no. 1515) cited *Carex foenea* [*C. aenea* as now understood] from Potts. On June 13, 1975, we found a boggy calcareous area rich in species (including *Cirsium muticum*) along the Au Sable at the present McKinley Bridge.

It is owned and operated by the same enterprising gentleman who is the proprietor of the Potts farm, heretofore described. Dinner was taken at the Comins farm, a refreshing bit of living green, several hundred acres in size, on the north bank of the Au Sable River.[44] Here Mr. Comins, the owner, makes a specialty of breeding Jersey cattle, pasturage being rank and abundant, proving again that certain varieties of grasses thrive encouragingly in this sandy region. Mr. Comins derives a large income from his stock experiments and is very enthusiastic regarding the possibilities of the much defamed pine barrens.

After dinner a score or more of the river lumbermen, who are stationed in the vicinity, sprang upon the floating pines, "peavies" in hand, and were photographed in various picturesque attitudes by Prof. Bailey, as they floated majestically down the rapid stream. The lumbermen enjoyed the novelty of the situation fully as much as did Prof. Bailey. Thursday night was spent at a primitive hotel in Mio, a village of perhaps half a hundred inhabitants, and the county seat of Oscoda County.[45] The scientific journey will be steadily continued to the westward from day to day until Lake Michigan is reached.

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[44]Coolidge M. Comins was one of the first four settlers in Oscoda County, in 1873. His buildings, where the expedition stopped at mid-day on June 14, 1888, were on the west side of Comins Creek at its mouth on the Au Sable, in sec. 11, T26N, R3E. The first school in Oscoda County was built by Mr. Comins on his farm in 1881. (See Au Sable, 1974, pp. 30, 52, 60.) Specimens labeled from Comins (not to be confused with the present community of the same name 10 miles directly north) have been seen as follows: *Carex houghtoniana* [58], *C. peckii, C. pedunculata, C. vaginata, Castilleja coccinea, Corydalis aurea, Geum rivale, Hepatica americana, Kalmia polifolia* (62), *Ledum groenlandicum, Petasites palmatus, Polygala paucifolia, Ranunculus septentrionalis* [53], *Symphoricarpos albus* [44]. Bailey's List also has *Smilacina trifolia* (63) and *Cynoglossum* [*boreale*] (59) for Comins. Beal & Wheeler (1892, nos. 1136 & 802) include *Corallorhiza striata* and *Cynoglossum* [*boreale*] among species attributed to Comins. A BH collection of *Cynoglossum* is labeled Oscoda County without further locality or number; since the date is given as June 15, we suspect this should be Crawford County, where the species was found at Frazer's (see note 50).

Several specimens are labeled "East Oscoda Co." for June 14 without further locality: *Andromeda glaucophylla, Cirsium hillii, Eriophorum spissum, Kalmia polifolia, Mimulus glabratus, Rosa blanda* ("6-13"–a day early). Several specimens similarly labeled are dated June 15; for these either the date or portion of the county is wrong: *Cypripedium acaule* ("Common in the pine woods and on the Jack Pine barrens where the Jack pines were large"), *Parthenocissus vitacea, Similax tamnoides* var. *hispida, Vitis riparia* (the latter two may be duplicates of Mio collections).

[45]The only hotel in Mio at the time was the Mentor House, which burned about 1893. Mio was settled in 1882, becoming the seat of Oscoda County, which was split from Alcona County in 1881. The present courthouse was built in 1888, when the population was closer to 150 (Polk, 1889; see also note 56). To this day, the village remains unincorporated; it has had a post office since 1882. (See Au Sable, 1974, pp. 5-8.)

Many specimens were collected at Mio, some dated June 14 and some June 15–the latter being possible before their departure "early on the morning." Collections from both dates are included in this listing: *Amelanchier spicata, Arabis drummondii, Carex eburnea* (46), *C. gynocrates* (77), *C. pedunculata* (48), *C. vaginata* (40), *Ceanothus herbaceus* [*C. ovatus*] (72), *Corallorhiza trifida, Epigaea repens, Equisetum scirpoides, Fragaria vesca* [42], *Habenaria obtusata* ("Cedar swamp bordering Au Sauble, in Pine barrens West of Mio"), *Hepatica americana* (50), *Ilex verticillata, Lathyrus ochroleucus, Linnaea borealis, Listera cordata* ("Swamp west of Mio"), *Lonicera dioica* [70], *L. hirsuta, Luzula acuminata, Menispermum canadense* (69; our northernmost record, and the leaves rather deeply lobed;

[June 18, 1888, page 4]

A BARREN WASTE.
The Agricultural College Exploration In Northern Michigan.
MOSQUITOES THE LARGEST AND MOST PROMISING PRODUCT YET FOUND.

GRAYLING, June 17.—[Special.]—The exploring party left Mio, the county seat and metropolis of Oscoda County, early on the morning of Friday, the 15th.[46] The route lay toward Grayling, through the interminable pine barrens, or "plains." These plains are clothed with a scant vegetation, the most conspicuous and common characteristic plant being the jack, or scrub pine. This pine is exceedingly variable. In the primeval groves it often attains a hight of from forty to sixty feet, and a diameter of a foot, or, in rare instances, eighteen inches. It is in these cases a tolerably comely tree, straight and erect, and would readily pass for a young Norway pine among those unacquainted with trees. When the trees have considerable room in which to grow they branch low and are then called "black jacks." These trees usually have much "sap" and are of little value for any purpose. The taller and straighter pines, which branch only toward the top, are commonly known as the "yellow jacks." Such trees have very little so-called sap-wood and are very much superior to the foregoing in quality. It is comparatively seldom, however, that one sees primeval groves or forests of jack pine. Fires often sweep over the plains, destroying all vegetation. Young pines soon spring up in these burnt areas, and in ten or fifteen years, if not killed, present comely and somewhat attractive groves of shapely trees from six to ten feet high. These groves of young trees are often miles in extent, and are so dense that the traveler is completely hidden from view at the distance of a few paces. From some eminence the observer occasionally gets a view of great expanses of this diminutive forest, the tops of the trees on the vast level stretches making a jagged pavement of green. Such expanses, melting away into

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cf. Beal, 1889, p. 180); *Nemopanthus mucronatus, Panicum depauperatum* var. *involutum, P. latifolium, Petasites palmatus* [49], *Polygala paucifolia* (75), *Pyrola virens, Ribes triste, Rosa acicularis* [several sheets; Bailey was evidently much impressed with the wild roses around Mio and assigned his numbers 64, 65, 66, 71 to them; one sheet is labeled "4 mi. W of Mio"], *R. blanda, Smilacina stellata, Smilax tamnoides* var. *hispida, Symphoricarpos albus, Triosteum aurantiacum, Vicia americana, Vitis riparia.*

Some additional June 14 species for which only "Cedar swamp" and the county are provided may well have come from the same site as, e.g., *Habenaria obtusata: Corallorhiza striata, Cypripedium calceolus, Ribes americanum* ("Swamp . . . 6-20-88"—clearly the date is wrong for Oscoda Co.), *Zigadenus glaucus.* Still additional species attributed only to Oscoda County, also June 14, and not thus far listed: *Erigeron pulchellus, Houstonia longifolia* ("Plains"; Bailey's List no. 73 says "Mio"); *Lycopodium clavatum* ("Jack Pine barrens"), *Lycopodium obscurum* var. *dendroideum* ("Jack Pine lands" MSC; "Plains" BH), *Picea glauca, Sisyrinchium montanum. Carex aenea* is dated June 15 for Oscoda County without further data; it may be from Potts Headquarters (see note 43).

[46]It is not certain exactly what route was taken west of Mio, the only landmarks identified being Ryno (see note 48) and Palmer's Farm (see note 49). It seems likely that the expedition stayed on the north side of the river to the Camp 10 Bridge site, and then after passing Ryno crossed again to the north side on the old Robinson or Upper State Road Bridge (see Au Sable, 1974, pp. 28-29). We were led to both bridge sites by Allen Nash, and walked on traces of an old road between them.

some mellow rise of ground or losing themselves in a distant valley, form a remarkable scene. At other times these young groves are peculiarly park-like in character, being marked by scattered and irregular clumps, between which are verdant and attractive openings. Often these parks are brightened by the lively green of stunted oaks and a few other brush-like trees. But however much the weary traveler may be allured by the distant view of these verdant openings, he is doomed to disappointment upon securing a nearer view. The sward-like glades are found to be clothed with stunted huckleberries or blueberries, miserable growths of sweet fern, and a few other pinched and starved plants which can endure the heat and dryness of the sands. There are no grasses of economic value, and none whatever which make a continuous sward. The June grass occurs along the crooked roads, where it has been inadvertently introduced by man, but it has not yet spread to any extent.

Of native grasses, the bunch grass or prairie grass, a species of Andropogon, is the most abundant and valuable. In some places it affords considerable herbage late in the season, but it does not appear to add much value to the plains. The absence of good native grasses is one of the most obvious proofs of the great difficulty which must attend the reclamation of these arid plains. To find a valuable grass which shall thrive here is one of the first and most important problems before the experimenter. This problem is one of the first which the Agricultural College is to attack. Already experiments are making in this line. Perhaps the most valuable plants which grow upon these plains, aside from the jack pines, are the huckleberries, but the bushes are small and poor. Three species grow here, but the bushes seldom exceed a foot in hight. The highbush or swamp huckleberry does not occur. The jack pine is used mostly for fuel, selling for about $1.25 per cord for stove wood. For this purpose the yellow jack is much better than the black jack. There has been an unsuccessful attempt to use the jack pine for various purposes in the arts. It is used somewhat for fencing, although it is almost worthless for posts.

On the whole the plains are exceedingly uninviting in aspect. The sand is deep and loose in the roadways, and the dust and heat are almost overpowering in these June days. The monotony and paucity of vegetation are almost painful. Nothing looks fresh and vigorous. Even the omnipresent jackpine is an untidy and unsightly plant as a rule. The lower limbs become dry and stiff, gray lichens cover the trunks, and even the normal aspect of the growing parts is sere.

What are the agricultural possibilities of the plains? This is the problem which awaits solution. So far, the prospect is anything but encouraging.[47] Many deserted homesteads along the route of the party attest to this fact. Other

[47]The *Alcona County Review* for August 3, 1888, observed: "The party of Agricultural College Scientists . . . gave a very unfavorable opinion of the quality of the soil found in our neighboring county of Oscoda. A correspondent of the Detroit Free Press takes exception to the finding of the scientists and says that if they had taken some other route than they did they would have discovered plenty of good farms . . ."

The Detroit *Evening News* for June 27 had also noted: "The scientific trip across the state by a delegation from the state agricultural college resulted in the collection of about 1,400 plants and in hard kicking by the local papers, which didn't like the way the Detroit morning papers handled the country in writing up the trip." (See also note 56, quoting the *Crawford Avalanche*.)

settlers are struggling hard against adversity of soil and climate, mostly with unsatisfactory results. In the Town of Harmon, near the postoffice of Ryno,[48] some eight miles beyond Mio, the party found a large opening and a number of settlers, some of the farms exhibiting signs of prosperity. Still the crop outlook is not encouraging. Rye is a common crop, but in most cases it does not promise a harvest worth the cutting. Wheat is rarely grown, and only occasionally some of the earlier varieties of corn. Potatoes are a prevalent and successful crop. Grass is largely grown upon the hard lands, but not upon the plains. The land is exceedingly susceptible to drought, and the sand becomes almost burning hot. If the jack pine should be largely cut off, the country must suffer still more, and there is no disposition in general to set trees of any kind. It is a gratifying fact that the jack pine springs up so readily to cover denuded places. Nature makes an effort to cover the nakedness of the soil and always succeeds beyond the expectations of the botanist who has read of the barrenness of the plains. But the soil coverings are plants which are known to frequent only the poorest regions, and little hope for the future of the country can be drawn from their stunted growth. But as hold-fasts and coverings for the soil they exert a great influence.

"Have you tried any fruit trees?" was asked of many settlers.

"Yes," said one. "I tried a few apple trees, but they died just above the snow line the first winter."

"I tried two or three cherry trees," said another, "but somehow they died out after a year or so."

"What varieties were they?"

"Oh, I dunno, Governor Wood was one, and can't tell about the others."

"What kinds of apples have you tried?" was asked of several, to which question the almost invariable answer was:

"Oh, I dunno. I got 'em for hardy uns and did'nt git the names."

These characteristic replies reveal the first difficulty in fruit-growing upon the plains—ignorance. There can never be even ordinary success in this industry in this region until men learn to know what they want to set and then insist that they get what they want. The man who does not know what he plants and who plants here such tender fruits as the Governor Wood cherry, need never expect a harvest of fruit. Some good patches of strawberries were observed at a few places on the barrens.[49]

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[48]Harmon Township (T26N, R2E) later became part of Big Creek Tp. The post office at Harmon was established in 1880—the first P.O. in Oscoda County. It was actually only about 5 miles west of Mio (probably in the SE¼ sec. 6 in 1888, on the old state road). The name was changed to Ryno in January of 1888, and the post office closed in 1899. (Charles E. Ryno, druggist, grocer, and justice, was postmaster 1885-1889.) The stage coach came three times a week, and the population was 125 in 1887 and 1889, but only 50 by 1891 (Polk). *Carex stricta* var. *strictior* [74] and *Rosa blanda* [67] were collected at Ryno June 15. *Corallorhiza trifida* was listed for Harmon by Beal & Wheeler (1892, no. 1133); a specimen of this labeled "E. of Frazers' place" and erroneously attributed to Iosco County probably represents this record. *Smilacina trifolia* was collected "east of Frazer's Harmon Tp." (see second paragraph of note 50).

[49]Two specimens are labeled from Palmer's Farm June 16, so apparently the route followed the river road through secs. 5 & 6, T26N, R1E, and not the main road, for the

It is said that sheep find good pasture among the jack pines.

The party arrived in Crawford County at sundown, and camped at Frazer's, a little farm occupying a picturesque bluff upon the upper Au Sable.[50]

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farm was in sec. 6 (see Holden, 1960, p. 87 and map p. 84). Oscar Palmer (1841-1923) moved to Grayling from Jonesville, Hillsdale County, in 1880 or 1881 and served as editor of the weekly *Crawford Avalanche* until 1912. A leading citizen of Grayling, he also cultivated interests in manufacturing, farming, real estate, and the law (admitted to practice in 1883, later becoming prosecuting attorney for Crawford County). (See Miller, 1963, pp. 125-135; Beal, 1915, pp. 359 & 493.) In view of the doubt cast by Miller on Palmer's medical credentials, it should be stated that he received his M.D. from Georgetown University, Washington, D.C., in 1863, but practiced actively for a total of only 8 or 9 years; he was an assistant surgeon during the Civil War, and served as medical director for the G.A.R., Department of Michigan, 1895-1899 (Beal, 1915, p. 493). He attended the Agricultural College briefly (1857-1858) and from 1889 to 1891 was a member of its governing body, the State Board of Agriculture. It is not surprising that the botanical expedition should visit his farm, but it is strange that no mention of it was made in the newspaper accounts (unless the farm is tactfully unidentified here). It is also surprising that the *Avalanche* has so little to say about the expedition (the three brief notices quoted fully in notes 22 & 56). Palmer attended the Republican convention in Chicago, according to the paper, and was probably there promoting the candidacy of ex-governor Alger (see note 39) when the expedition passed through Grayling.

The specimens are *Andromeda glaucophylla* ("Dr. Palmer's Farm 16 E. Grayling" in Wheeler's hand, BH) and *Viola pedata* (MSC, "Palmer's farm. Pine barrens" labeled in the usual unknown hand, the number of miles east of Grayling torn from label). Since one label for Palmer's farm cites it as 16 [miles] east of Grayling [it was actually closer to 18, even in a straight line, not by road], and the farm was only half a mile into Oscoda County, we may assume that localities given as 15 miles and less east of Grayling were all in Crawford County (see note 51).

[50]In 1880, Roderick ("Rory") Frazer [or "Fraser," or "Frazier"] built a hostelry, the "Halfway House," in the SW¼NW¼ sec. 26, T27N, R1W, on the high east bank of the North Branch of the Au Sable below the mouth of Big Creek. Here, a high pole bridge carried stagecoach traffic across the river, a little less than a mile south of the later well known Kellogg's Bridge. (See Miller, 1963, pp. 39-40; Holden, 1964, fig. 3, p. 287.) Frazer and his wife did some farming at their establishment. The *Crawford Avalanche* for June 14, 1888, noted: "R. Frazier is making a garden of his farm on the North Branch." Long after the Frazers had left the site, the Halfway House burned (in 1936, says Miller, 1963, p. 40), leaving the ruins of a stone chimney. The chimney stands yet in 1975, and remains of the wagon road and pole bridge are evident immediately to the south of it. We were especially pleased to find here, on June 14, on a springy bank, the rather rare sedge, *Carex schweinitzii,* for that is the species which started our whole investigation. Specimens of it (MSC) were labeled as from Oscoda County, but Beal & Wheeler (1892, no. 1393) said "Near Frazer's, Crawford Co.,–Prof. L. H. Bailey," clearly referring to this expedition. Indeed, the site seems to have been *very* near Frazer's, right on the south side of the stage road at the bridge! We also quickly found here several other species found in 1888; it was a good collecting site then and now. (See Fig. 18.)

Some collecting must have been done upon arrival "at sundown" June 15, 1888, as well as early the next morning. Records from Harmon Tp., Oscoda County, "east of Frazer's" are clear (see end of note 48). Otherwise, in view of the richness of the habitats on the North Branch here, we assume that all collections labeled as from "near" Frazer's did indeed come from very near, and not from two or more miles east, in Oscoda County, regardless of the fact that labels often say Oscoda County (see Holden, 1960, for comments on the ease of confusion as to location of the county line in this region). Species collected June 15 and 16 at Frazer's, all presumably from Crawford County, have been seen as follows: *Carex aurea* (90), *C. flava* (83), *C. granularis* [89], *C. houghtoniana* (91), *C. leptonervia* [84, as *C. laxiflora* var.], *C. peckii* (88), *C. schweinitzii* (79), *C. tenuiflora* [85], This is the tidiest farm which the party has found in the woods, and some fairly good crops were observed. It is proper to remark, however, that the soil upon this farm is better than the general run of the sands. The mosquitoes at this place were particularly corpulent and agile, and withal provokingly domestic in their habits. They pulled the blankets off the sleepers at 4 o'clock in the morning, and exulted to madness over the enforced early breakfast taken by the yawning party. The party early resumed its march to Grayling, crossing the lowlands of the river onto the miserable plains. In these plains the journey lay all day.[51] Some of the party enjoyed the conception of utilizing the region for raising of post-holes,[52] while another would convert it into a national cemetery. One person utterly failed in an attempt to pull out a fox-hole for a museum specimen, although various other characteristic productions of the region were successfully piled upon the feet of the reporters. The sun beat down with fury, and the sandy road seemed as if burning. Occasionally an unfortunate bird chirped from a jack pine, and once a squirrel was seen to run lazily along a brush fence. Nearly all other life, except the murderous mosquito and an occasional

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Cynoglossum boreale [87, if collected June 15 as labeled, although the label says Oscoda Co. without further locality; we found the species on the embankment at the former bridge location at Frazer's], *Kalmia polifolia* (93), *Petasites palmatus, Prunus pumila, Salix pedicellaris* [94, 95], *Scirpus hudsonianus* [3 sheets, MSC, BH, GH, all say Frazer's, and the MSC sheet adds "B. meadow" on a label in Wheeler's hand; another MSC sheet in the usual unknown hand says "Beaver meadow 15 mi East of Grayling" and is probably a duplicate, since 15 miles would in fact be close to Frazer's], *Senecio pauperculus* [80]. Bailey's List also includes for Frazer's: *Carex [rostrata]* (81, "Young and worthless"), *C. [lacustris]* (82, "Young and worthless"), *Cardamine pratensis* (86), *Viburnum cassinoides* (96), and *Anemone [quinquefolia]* (97, as A. "nemorosa L. pubescent"—anticipating Fernald's description of the pubescent var. *interior* in 1935). The last entry on Bailey's List is no. 109, *Rosa,* "June 18 Frazers" but the date and locality are clearly contradictory and there is no way to determine which is correct.

[51]Several collections are labeled as from east of Grayling June 16, without named locality: *Anemone quinquefolia* ("In swamp . . . 9 mi east of Grayling"; this would not be far enough east for Frazer's, from which Bailey listed the species—see preceding note), *Betula pumila* ("East Crawford Co. 6-17-88"; the date and locality are contradictory, as the party camped the night of June 17 at Grayling, in the center of the county), *Carex lucorum* ("In tamarack swamp 10 mi east of Grayling"), *Lonicera oblongifolia* ("12 mi. E. Grayling"), *Vaccinum myrtilloides* ("Tamarack swamp 12 mi. E. of Grayling").

[52]Bailey modestly avoids attributing the post-hole concept to himself. The *Tribune* reporter described the conversation more fully, and ascribed it to the region west of Appenzell (compare also Figs. 9, 13, and 17):

"The road was hot and dusty, and the professors, who had not found many good botanical specimens of late, were getting weary. The stubborn-looking sod was beginning to discourage them, with its everlasting blue horizon and scraggy clumps of jacks, with occasional openings and buried places. It suggested a vast cemetery without the tombstones.

"'This sod isn't worth three cents an acre. I wouldn't live here for the whole country,' observed Prof. Wheeler with a yawn.

"'Oh, pshaw, this soil's good for one thing anyway,' remarked Prof. Bailey, crushing a mosquito.

"'What's that, what's that,' asked Prof. Beal eagerly, at the prospect of having a new hope in the discouraging prospect.

"'Why, use it to dig telegraph pole holes in—it's just the thing.' . . .

"There was not even a saw mill to relieve the monotony. The few farms, either abandoned or with thin, meager crops and finished with rough log buildings, which seemed a part of the wilderness itself, were the only things of interest passed."

ambitious sand-fly, was wanting. But two birds' nests have so far been found upon the plains.[53] The party rested for dinner at a comfortable half-way house, built snugly among the jack pines with scarcely a clothes yard for an opening, and then resumed its course over the sand. The afternoon was relieved by the finding of several ant-hills. Two or three beaver meadows and old dams were also visited. Near the half-way house the scattering little settlement of Appenzell was passed. This settlement is composed of Swiss who appear to be making a living.[54] At 3 o'clock the party arrived at Grayling,[55] the thriving town which is said to live upon fish and strangers.[56] At this place is the central experiment

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[53]One wonders how close the exploring party came to a major ornithological discovery, which obviously they missed even though they were in the right place at the right season—and they must have passed through stands of jack pine of suitable age and density for nesting of the Kirtland's Warbler, now officially an "endangered species," which nests nowhere else in the world except the jack pine plains of northern Lower Michigan. The population of the bird was probably several times as large as today during the period 1885-1900, at the peak of lumbering and fires (see Mayfield, 1960, pp. 25-27). Although the warbler had been taken in the state as a transient in Washtenaw County as early as 1875, the first discovery of it on its breeding grounds was on June 15, 1903, by two University of Michigan students who were trout-fishing along the Au Sable near the Oscoda-Crawford county line. Their camp and discovery were less than a mile north of Frazer's. The next month, N. A. Wood found the first actual nest of this bird, in westernmost Oscoda County, perhaps along the same road as that taken by the 1888 exploring party. (See Holden, 1960; 1964.)

[54]The *Tribune* mentions that Appenzell "consisted of two houses and a postoffice where the mail was delivered three times a week." (Mail service was only weekly according to Polk, 1889.) A post office (which operated until 1895) had been established in 1886, with John J. Niederer as postmaster. Miller (1963, pp. 137-138) states that Niederer had named the location Appenzell after his birthplace in Switzerland, and that the site was later known as Sigsbee. The population was given as 20 during the 1887-1891 period (Polk) and the location was along what is now the North Down River Road a mile or less east of Stephans Bridge Road (i.e., sec. 33, T27N, R2W, & sec. 4, T26N, R2W). Very few collections are explicitly labeled as from Appenzell: *Carex aurea* (105), *C. flava* (98), *C. sterilis* (99), *Scirpus hudsonianus* (100).

[55]The *Tribune* account (June 18) describes the arrival at Grayling: "There are about twelve hundred people here, with several good business streets, water works, electric lights, mills and fine public buildings. . . . Here was balm for the professors and students, who immediately set about getting a bath and a hotel meal, both very much needed after a week of sleeping in tents and without taking off their clothes and dining off stale bread and ham and other aged delicacies of camp life. A camp was pitched close to Deputy Sheriff Metcalf's house on the edge of the village."

Grayling was settled in 1872 and then named Crawford, the same as the county. Although the station on the Michigan Central Railroad continued as Crawford for some time, the community changed its name in 1874, when the post office was established, in honor of the renowned fish (see note 76). Grayling became the county seat, succeeding Cheney (Pere Cheney) about 1880, and was incorporated as a village in 1903.

[56]It is interesting to see this phrase used by Bailey here to describe Grayling. The *Tribune* reporter, in his dispatch published June 14, quoted the wagon driver in reference to Harrisville, "they must live here on fish and strangers" (Metcalf was upset at "having to pay $1.75 for an hour's stabling for his horses"). Evidently the phrase was not well received locally, as the *Crawford Avalanche* on June 28 quoted its Grayling rival, the *Northern Democrat*: "The Free Press correspondent who is accompanying Professor Beal's party across must be exceedingly cute or else terribly homesick when he speaks of Mio as a town of perhaps half a hundred inhabitants and Grayling as subsisting chiefly on fish and strangers." The staunchly Republican *Avalanche* replied: "There was nothing cute in either

Fig. 9. Jack pine plains, Crawford Co., June 16, 1888. (Photo by L. H. Bailey; from M.S.U. Archives & Historical Collections.)

farm for the plains, under the charge of the Agricultural College. This farm comprises eighty acres donated by the Michigan Central Railroad company, and eight acres of leased land.[57] The leased land has 250 rod-square patches laid out upon it, seventy-five of which are now sown or planted to various experimental plants. The eighty acres have been inclosed by a board fence, and a part of it has been broken up this spring. Most of it will not be ready to crop this year, although Dr. Kedzie has sown various plants which are reputed to endure great drought and heat, and Dr. Beel [sic] has set out forty kinds of hardy forest trees. Some of these trees have been set upon plowed ground in rows, others have been set among the jack pine, where nothing but a harrow has been employed, and still others have been planted among the pines upon unmolested

his report or your comment. It was only another instance of democratic stupidity, and the Free Press did the people of this section and the State generally a great wrong in sending such a callow unformed youth on a mission of so much importance." Did the writers know they were referring to the reporter for the understatement of Mio's population but to Prof. Liberty Hyde Bailey otherwise?

[57]Whether the railroad gave land to the College in a futile hope of promoting agriculture—and hence business—in the region, or out of a generous public spirit, we do not know. But one might suspect that Gilbert H. Hicks had something to do with it. For Hicks (see Voss, 1956, pp. 32-33) was an active amateur botanist, while serving (at least since 1884) as station agent for the Michigan Central Railroad in Grayling. There is no direct evidence that the exploring party visited Hicks while passing through, but there is good circumstantial evidence that Hicks must have received a "pep talk" on *Carex* from Bailey. For on June 18, the day after the party left Grayling, he collected at least six species of *Carex* (specimens in MICH). In 1890, Hicks went to the Agricultural College as a student, graduating in 1892. From 1894 until his death in 1898 he was with the U.S. Department of Agriculture in Washington.

ground. It is the object of these tests to determine the most economical means of growing the trees, as well as to determine the species best adapted to the plains.[58]

L.H.B.

[June 21, 1888, p. 4]

IN THE WILD WOODS.

The Valuable Pioneer Work of the Experiment Station.

THE GRAND VIEW DOWN THE ROAD THROUGH THE WOODS.

CAMP IN THE WOODS, KALKASKA COUNTY, June 18.–[Special.]–The picturesque exploring party left Grayling Sunday afternoon westward bound.[59] The sun was intensely hot[60] and the team plowed lazily through the heavy and dry sand on the road to Portage Lake. The party called on Shop-ne-gaunce, the chief of the local Indians. He resides in a conspicuously painted house in Grayling standing along the Au Sable. He is an Indian of medium stature and unusually intellectual face. The party of strangers who called upon him was so formidable that the old Indian became taciturn and refused to respond to the suggestive questions of THE FREE PRESS correspondent, and even when asked a direct question would respond, curtly and vaguely, that Shop-ne-gaunce was not in a mood to be interviewed. The chief of a few scattered and broken families of Indians is an Indian still. He has not imbibed enough of the white man to make him desirous of publishing his affairs. The ordinary six-penny official among ourselves is only too glad for an opportunity to display his puny efforts and to air his importance, even though he curse the reporter the while. Shop-ne-gaunce has three cub bears some 6 months old, which he captured last winter. To some of his intimate friends he has rehearsed the details of their capture and his narrow escape while disposing of the mother bear. This story, as told by his neighbors, is an attractive one. Certainly your correspondent must hear it.

"Where did you get the cubs?" asked the reporter, as the active young animals performed various ludicrous antics about the yard.

"Oh, me get 'em," was the reply.

"But where did you get 'em?"

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[58]See note 28 and the associated *Free Press* text for information on the experimental farm at Grayling. The region never became an agricultural center, although there had long been efforts in that direction (Miller, 1963, pp. 55-57; 64).

[59]According to the *Tribune,* "Dr. Beal visited his experiment farm in the morning" and the expeditionists visited the Indian chief, Shop-ne-gaunce, just before leaving Grayling about 4:00 p.m. Several collections were made at Grayling June 16-17: *Amelanchier arborea* (104), *Arctostaphylos uva-ursi, Carex adusta* (106, see note 63), *C. oligosperma, C. paupercula* ("East Grayling"), *Gaylussacia baccata, Helianthemum canadense, Ledum groenlandicum, Kalmia angustifolia* and *K. polifolia* (see note 62), *Linnaea borealis, Nuphar variegata* ("Marl bottom lake near Grayling"), *Pinus banksiana, Prunus virginiana* ("West of Grayling"), *Vaccinum myrtilloides* [101], *Viola pedata.* Some of these may have been found along the road to Portage Lake (see notes 62-64).

[60]Evidently this period of June, 1888, was indeed unseasonably hot, from Manitoba to the east coast. Official weather records were not then being taken at any station along the route, but the *Free Press* for June 18 noted that on the previous day the mercury had reached 95 in the shade at Saginaw.

"Swamp."

"Where is the swamp?"

"Injun me git 'em swamp," replied the Indian, pointing lazily towards the woods.

"Did you have trouble getting them?"

"Yeh."

"Did you kill the old bear?"

"Yeh," stolidly.

"When did you get them?"

"Last winter get 'em me."

All further questions were either entirely ignored or answered by the convenient "Yeh."

Shop-ne-gaunce is a picturesque character at Grayling. He is perhaps 65 years old, and has a family of three or four children. He lives by trapping, hunting and fishing, and by acting as guide for various pleasure seekers who delight in rehearsing their experiences with Indians.[61]

The road from Grayling to Portage Lake, a distance of some four miles, is the hardest which the party has yet encountered. It is deep and dry sand, through which the wagon moves with great difficulty. But the drive is an interesting one, inasmuch as it crosses the divide between the Au Sable and Manistee Rivers. Grayling lies upon the Au Sable, while Portage Lake discharges into the Manistee. After crossing a strip of lowland, perhaps a half mile broad, one begins a very gradual ascent. The divide is scarcely perceptible, and one cannot determine when he is upon the highest point. A peculiar dry heath swamp occurs along this highway, in which grow two attractive laurels,[62] one of which had not been seen before since the party left Harrisville. The collection of plants along the line of travel awakens the interest and curiosity of the lumbermen and settlers, and in not a few cases provokes the most preposterous remarks. Stage Manager Metcalf begins to see beauty in "weeds," and now spends a good portion of his time in walking ahead of the wagon, clutching at everything which appears new. This afternoon he is particularly attentive to the wayside, and soon brings up with a plant new to Michigan. In a purely scientific way the expedition is obtaining gratifying results, for there are not many regions in our older States where native species new to its territory can be picked along the roadside.[63]

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[61]David Shoppenagon, as his name came usually to be spelled, died in 1911 at the reputed age of 104—which would have made him 81 and not 65 in 1888. Miller (1963, pp. 70-71; 75-83) tells more about this well known Indian, and quotes Esbern Hanson as recalling Shoppenagon's three bear cubs when he (Hanson) was about 12 or 13. Since Miller (p. 79) refers to Hanson as an octogenarian, he might well have been 12 or 13 in 1888 and the story refers to the same cubs that the botanical expedition saw.

[62]Both laurels, *Kalmia angustifolia* and *K. polifolia*, were collected on June 17 and labeled as from Grayling (note 59). The later-blooming *K. angustifolia* was conspicuous June 14, 1975, under jack pines between Lake Margrethe and the Manistee River.

[63]The species new to Michigan found by Metcalf was presumably *Carex pinguis*, which had been described by Bailey in 1887, but which was already included by him in the synonymy of *C. adusta* in 1889 (Mem. Torrey Bot. Club 1: 25; Watson & Coulter, p. 621; in both places Crawford County is cited on Bailey's authority). Bailey's List gives *C. pinguis* as no. 106, "Near Grayling. June 17" and a sheet with this number, originally named *C. pinguis* but changed by Bailey to *C. adusta*, is in BH.

Portage Lake is a beautiful sheet of water some six miles long by three broad, clear and pure, with a sandy bottom.[64] It abounds in fish, as the party proved to its satisfaction. The lake is nearly surrounded by a primeval forest of pine, which, however, is being rapidly removed by the lumbermen. Logs are being dumped into it daily in immense numbers. They are collected in booms and towed across the lake by a tug and are then loaded on to a logging railroad and carried two miles, where they are dumped into the Manistee. The tug of one firm, Salling, Hanson & Co., handles 200,000 feet per day, or about 2,000 logs.

The tent is pitched upon a low bank overlooking the lake, the coffee boils over and spatters upon the chip fire, the white throated sparrow pipes his metallic call from the adjoining thickets, a whippoorwill calls from the trees, and the perennial conflict with the mosquito has begun. Twilight settles down upon the lake and forest and a great silence envelopes all nature. The crisp breeze which a few minutes ago breathed softly from the lake dies away. With the coming of night comes also the "Doctor," an eccentric character of an adjoining camp. Thoreau declared that he never got so far into the woods that he did not find someone going farther. It is equally true that one never finds a settlement or a camp so remote that he does not find some peculiar individual to whom all others turn with somewhat of reverence. It is a singular fact that some wholly eccentric old man will often hold the admiration of every loafer and braggart in a lumber camp, although there may be no interest in common and no mutual acquaintance. Soon after the appearing of the genial old doctor the party grew talkative and stories went the rounds, each narrator going his companion "one better," and prefacing the yarn he is about to spin with the most solemn and consequential remarks concerning its truthfulness.[65]

Passing Portage Lake one finds the omnipresent jack pine and the accompanying sandy lands.[66] The lands are better here than west of Grayling. The bunch grass is more abundant, forming, in many places, an almost continuous

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[64]Portage Lake, later named Lake Margrethe (for the wife of Rasmus Hanson), was on the old Indian portage between Grayling on the Au Sable River and the Manistee River. The route taken from Grayling by the covered wagon must have been about that now represented by highway M-93, although no such road shows on the 1884 Atlas (Walling); the deep sandy road would have been quite new in 1888. The night's camp was probably at the present site of the Michigan National Guard Camp, or a bit north of it, from which there is a view across the lake similar to that in Fig. 10. Species collected at Portage Lake June 17-18 and thus labeled are *Festuca saximontana, Linnaea borealis* (also collected "Near Grayling"; possibly the same site is meant by both labels), *Vaccinum brittonii, V. lamarckii* (originally determined as *V. vacillans* and *V. pensylvanicum* respectively, and on Bailey's List under these names as nos. 102 and 103).

[65]The *Tribune* report published June 21 gives a longer account of the visit from "Dr. George Whitcomb, who is a pioneer of Michigan, and who at present is veterinary surgeon for the lumber camps in this vicinity. He is nearly seventy years old."

[66]There seems to be no way to determine how the party traveled from Portage Lake to Kalkaska County; no roads show in the 1884 Atlas (Walling) which would connect with Glade Township (see note 69). Perhaps there was a route straight south from Portage Lake to Cheney Road, or perhaps one angled southwestward to the county line and then went at most one mile south to Cheney Road. Later maps show several roads, and since we cannot tell which existed and was taken in 1888, this portion of the route is not shown in Fig. 1.

Fig. 10. Campsite on the shore of Portage Lake [Lake Margrethe] June 17-18, 1888. Photo presumably for L. H. Bailey, who is standing; D. A. Pelton is seated. (From Kuhn, 1948; original photo not located.)

sod. This country promises well for sheep grazing, although no sheep have yet been introduced. Sheep eat huckleberry brush also and sometimes browse the sweet fern. The country becomes very rolling, the road passing over the interesting formation known to geologists of the terminal moraine.

The country east of Grayling, however, comprises the typical plains.

The soil of these typical plains is light sand, with the firm subsoil very low. In many places the soil is somewhat gravelly, but the gravel is loose and lacks substance. The plains are "leachy" lands; that is, the rain is not retained long in the soil, but passes through rapidly into the subsoil, and the capillary power of the soil is so little that moisture does not rise from below to any extent. The filtration of water through this clean sand gives excellent water in the wells in all the plains' region. For the most part the wells are shallow, ranging from ten to twenty feet. Most of the brooks, which, by the way, are very infrequent, contain sweet and pure water. These creeks and the rivers, most of which lie in considerable valleys, are fed by numerous springs along the banks, the drainage of the plains.

While it is true that the characteristic plants of the plains are such as will not awaken the interest of the casual observer, there are some remarkable exceptions to this statement. Some of the plants are worthy a conspicuous place in the flower garden. The life root, or senecio of the plains, is very common in places, decking the dull surface with masses of golden yellow.[67] The yellow puccooon [sic], two sorts, is also conspicuous and attractive. Much of the barren land, especially on the eastern side of the State, produces great numbers of the large wake robin or trillium, a plant ordinarily found in low and rich woods. The bird's-foot violet, the handsomest of the native species, gives the ground a bluish cast in some places, its great flowers appearing to delight in the aridity of the plains. Upon the plains of Oscoda County beautiful wild roses are abundant, the bushes sometimes attaining a hight of four or five feet and bearing a profusion of large and bright flowers. A species of New Jersey tea often whitens the slopes with its compact clusters. The occurrence of these plants cannot fail to inspire the hope that other plants of economic value can be made to grow profitably upon the plains. For the most part, however, these plants are such as delight in the poorest sands. The experimenter should seek rather to discover plants which naturally thrive upon loose sand than to attempt to cultivate here the ordinary plants of the farm and garden. Upon this line of experimentation the Agricultural College is working, with the means derived from the operation of the Hatch law. Any plants of agricultural value which are adapted to sandy land will be given a trial upon one or all of the test farms. Already many plants from Europe and other countries are being tried, especially in the way of forage crops. It is to be expected that many of these plants will fail, but there is reason to hope that a few years will reveal some valuable acquisitions. Progress will necessarily be slow, and very likely the last to be benefited by the experiments will be those who live near the experimental farms. Already there are numbers of people who ridicule the plan of work and the methods employed, but they are among the ignorant classes, who are always jealous of progress. The plains lands are not yet in demand for farming purposes, and the experiment stations are therefore bound to do pioneer work. When the better lands are all settled, it is probable that these stations will have determined a measurably profitable line of agricultural industry for the plains. In this work the stations will derive great aid from the few farmers who are attacking the problem single handed. It is not to be expected, however, that all the plains shall ever fall to strictly agricultural uses. Large tracts are being bought up by organizations of sportsmen for game reserves. When such tracts can comprise considerable diversity of surface and timber, with section of brook or river or lake, they are capable of making satisfactory ranges for game.

The surface of the plains is diverse. It is mostly made up of a broad system of terraces which rise from the Au Sable, Manistee, Muskegon, and other rivers. Adjoining the river is an alluvial soil, variable in width, but usually confined to a few rods. From this rises a terrace of fifteen or thirty feet, leading to a level stretch of plain. Above this is another terrace, often higher than the first, and above this still one or two others. The width of the intermediate stretches varies

[67]The common tall *Senecio* of the jack pine plains is apparently a form of *S. pauperculus,* often more tomentose than usual, although we do have *S. plattensis* in the state and intergrades may be expected (see Barkley, Rhodora 65: 65-67. 1963). The other plants mentioned in this paragraph may be identified as follows: *Lithospermum caroliniense* (puccoon), *Trillium grandiflorum, Viola pedata, Rosa acicularis, Ceanothus herbaceus* (New Jersey tea).

from a few rods to a mile or more, until the hight of land is reached beyond the valley. The valley of Au Sable varies from three to five miles in width. The high lands to the rear of the last terrace are often one and two hundred feet above the river bed. They are mostly undulating in character, although, in many places, there are long stretches of perfectly level country. Some of these stretches which have been recently burned and over which the low herbage has again gained a foot hold have the appearance of great pastures. One of these openings, fully two miles long, was passed through.

It is to be borne in mind, however, that the plains do not comprise the whole territory through which the exploring party is making its progress. Nearly all of Alcona County is excellent farming land, fully as good as one finds in our southern tier of counties. The timber is hardwood and mixed forest, with dense undergrowths quickly springing up in the clearings. The country is rolling and handsome, and comparatively well watered. We are informed that the northern half of Oscoda County is much the same, and there is considerable hard land in Crawford County. Throughout all the plains region there are occasional strips of hard land. The character of the plains soil itself is somewhat variable, some streaks of sand being much more fertile than others. Much of the pine land appears to be no better than the plains. It appears that a considerable part of the plains lands is made such by the action of fires, which prevent the trees from attaining a great size, for upon most of the plains one finds young Norways starting up, and it is rare that there are not unmistakable evidences of fire having swept the country at one time or another. Before the plains can be reclaimed to the farmer for purposes of forestry and grazing there must be devised some means of lessening fires. Under the present slovenly and careless system of timbering there is little reason for hope in this direction.[68]

The logs are taken from the tree and all its remaining portions are allowed to remain where they fell. As soon as they become dry fire gets started in the slashing and spreads rapidly, burning over plains as well as timbered lands. What little herbage the plains afford is burned off, instead of passing into the ground to enrich it. In this manner a continual impoverishment of the soil is progressing. Lumbering and farming are largely antagonistic industries. At least one does not thrive in the presence of the other. The era of lumbering will be gradually followed by one of agricultural activity. In the meantime, the experiment stations will be doing good work. The sooner the lumber is taken out the sooner will the permanent prosperity of the country begin. The hardwood lands are in

[68]The *Tribune* for June 21 also commented at length on the desolate burned areas:

"On the trip several immense burned tracts have been passed through. Many of these stretch for miles in the great woods, and their hideous, black aspect gives the picture of complete desolation. Nothing green whatever is to be seen in them. Many of the large charred trunks still stand, while most of them have fallen in heaps, and their black forms seem to mourn the life once enjoyed.

"'The cause of these fires, especially these extensive burnings,' said Dr. Beal, 'is that the lumbermen who have cut out the large trees here and left the smaller ones, have allowed the lopped off branches and refuse timber to lie and dry up, when the trees were cut in the forest. Some careless hand has set these dry tinder-like piles afire and the blaze has run wild through the woods, destroying everything before it. The timber is going off fast enough in this country without that.'"

much less danger of injury from fire than the pine lands, and it is not so essential that they should be rapidly decimated of their timber. Most of the remaining pine forests are in imminent danger from fires, and it cannot be expected that they should stand much longer.

The party arrived at Dempsey's Camp, in the extreme southeastern corner of Kalkaska County, the headquarters of the Manistee Lumber Company, at noon on Monday.[69] A dinner was served for the company in a commodious log cabin. A clean and palatable dinner soon satisfied the marvelous appetites of the travelers.[70] Dempsey's Camp comprises eight or ten log cabins, standing along side the narrow gauge track owned by the company. This track extends eastward nearly to Grayling and westward six miles to the Manistee. Nicholas Dound, the foreman of the camp is one of those hale and well-met woodsmen of noble

[69]The backwoods post office [Fletcher] was visited Monday morning according to the *Tribune* for June 22 (see note 73); the second paragraph below in the *Free Press* account is somewhat misleading in giving the impression that Fletcher was encountered after Dempsey's. Once in Kalkaska County (see note 66), the party must have traveled straight west on Cheney Road, an old "state road" crossing the middle of T25N, R5W, the southeasternmost township in the county and then called Glade Township (now the easternmost of three survey townships included in Garfield Tp.). We are indebted to the investigations of Fred Hirzel, now aged 90, for evidence that the Fletcher P.O. (as he recalls testimony of his father and others) was once at the northwest corner of sec. 22. The relatively large trees at this site, which we visited with Mr. Hirzel, do suggest some settlement in the past, of which no trace remains. The Dempsey Camp visited, then, would have been about one mile west, where the railroad grade is still visible crossing Cheney Road (this is just a little over 5 miles along the grade from the Manistee River—close to the "six miles" noted in the *Free Press*). Here, the party probably turned south for one mile, continuing west on what now is Sharon Road, and angling northwest on it to Jam One [Sharon]. Mr. Hirzel states that the Fletcher P.O. had at least five locations during its existence, to suit the convenience of the lumber company; hardly any two maps show it at the same site. (See also Fig. 19.)

An 1884 map (Page) shows a road across the north part of the township, passing "Glade P.O." near the southwest corner of sec. 3 (i.e., about two miles north of Cheney Road). This road continues to the Sharon locality across what later maps call the "Big Devil Swamp" and on topographic grounds this seems an unlikely location for an early road; furthermore, this route does not follow the section lines, as Bailey describes the 1888 route, and it would not pass a Dempsey camp six miles from the Manistee. No office by the name of Glade or Fletcher is listed in the Page history (1884, p. 324) among the post offices of the county, even though the former is mapped (perhaps only a prediction?). Romig (1972) apparently never encountered a P.O. named Glade. The Fletcher P.O. was opened in the Giddings farmhouse in 1883, according to Romig, and it was still there when the 1888 expedition passed through. Before the P.O. closed in 1912, it must have moved frequently, as was the custom with "farmhouse offices" of the day.

[70]James Dempsey was president of the Manistee Lumber Company and of the company's Crawford & Manistee River Railroad; his name dominated the part of Kalkaska County where their logging operations were conducted. The cooks at the Dempsey camps were famed. Fred Hirzel writes (pers. comm., 1975): "From my father's store at Moorestown we sold Dempsey many hundreds of pounds of butter and thousands of dozens of eggs, and especially, dressed hogs and beef, by the side or by the carcass." It was probably the experience here which led Beal (in Beal & Garfield, 1888, p. 34) to write of a lumber camp: "The dining-hall looks much like the lodging room, only two rows of long tables with oil-cloth covers stand lengthwise of the room. Near the table are rough benches, and for the meal substantial food like potatoes, bread and butter, pork and beans, fresh beef, and coffee, are supplied in abundance and eaten with apparent relish.... At these camps, travelers can procure meals, as at a tavern, paying the customary price of twenty-five cents."

Fig. 11. Locomotive (36-inch gauge) bought by the Crawford & Manistee River Railroad (James Dempsey, president) in 1885, when the line opened, and doubtless in use at the time the expedition visited Dempsey's lumber camp in Glade Tp., Kalkaska Co., on June 18, 1888, for the line had but one locomotive operating on its 13 miles of track at the time (Poor, 1889). The name "Nicholas" faintly visible on the side recognizes Nicholas Downs, superintendent of logging operations for the Manistee Lumber Company. (See also note 78.) (Photo from the Fred C. Hirzel collection, no. 134.)

physique, who at once commands the admiration of the visitor.[71] He handles 125 men in the camp without friction. These men handle 100,000 feet per day. The company owns most of the Town of Glade, comprising a forest of white and Norway pine about equally mixed. The present camp has been in operation three years and five years will be required in which to complete this block of lumbering.

The route for the afternoon lay through a variable country. The greater part of the journey, however, was taken through primeval forest of great luxuriance and beauty. It passed through several miles of mixed timber of which the predominant feature was the occurrence of mammoth white pines. The largest pine seen had a girth of sixteen and one-quarter feet at two feet from the ground. The finest white pines grow in these mixed forests, while the best Norways usually occur in continuous forests of that one species. In the magnificent mixed forests just noted the white pine does not comprise one-fourth of the total number of trees, yet lumbermen regard it as almost ideal white pine forest. The Norways grow straight and tall, their lithe and smooth trunks standing close together and presenting a picture of marvelous grace and

[71]Fred Hirzel (pers. comm., 1975) says that Nicholas Downs (whom he knew as a boy) was superintendent of all logging operations of the Manistee Lumber Company. The name NICHOLAS is faintly visible on the side of their locomotive, shown in Fig. 11. We have not been able to verify the spelling of the surname.

Fig. 12. Road through a dense forest of pines, Kalkaska Co., June 19, 1888. Although dated the 19th, this illustrates well the terrain described for the afternoon of June 18. Compare the present appearance of Cheney Road (Fig. 19). (Photo by L. H. Bailey; from M.S.U. Archives & Historical Collections.)

beauty. Through these great primeval forests the roadway winds as a mere thread. At points the road is straight for a long distance, and the view down the long aisle, with its fleckered pillars of Norway, fading into deep shadow in the far distance, is grand beyond all description. [Fig. 12] At times the road plunges down great valleys into obscure masses of verdure, apparently losing itself abruptly in an overhanging thicket. Again it follows the highest ridges, which are often burned clear of all arboreal vegetation, affording the traveler broad views of the surrounding wilderness. This road is an irregular, winding one, occasionally blocked by trees and washouts, often very rough, but usually tolerably smooth, at least in the sandy lands. [Fig. 13] From Lake Huron to Grayling the thoroughfare is a neglected State road, cut out some twenty years ago.[72] When we reached Kalkaska County it was found to take to the section lines in most places.

A short distance from Dempsey's camp is Fletcher postoffice. A visit to this office revealed one of the most primitive of Uncle Sam's possessions. A very small log house and a log barn adjoining stood in a bare clearing. The FREE

[72]The party obviously detoured several times from the main State Road, e.g. to pass through Potts Headquarters [McKinley] in eastern Oscoda County (see note 43), whence they would be likely to have taken a route along the river northwestward back to the State Road; and to visit Palmer's Farm, in westernmost Oscoda County (see note 49). The *Tribune* reporter, in his dispatch from Mio dated June 15, published on June 16, and reprinted in the *Alcona County Review* June 22, observed that the road in Alcona County "followed for many miles a lumbering branch of the Detroit, Bay City & Alpena railroad, which winds in and out among many prosperous looking lumber camps."

Fig. 13. Road through rolling barrens, Kalkaska Co., June 18, 1888, probably somewhere southeast of Jam One [Sharon]. (Photo by L. H. Bailey; from M.S.U. Archives & Historical Collections.)

PRESS correspondent approached the bare cabin and accosted a grizzly and bare-footed man who stood near by and who responded to the honor of postmaster.[73] We called for a special delivery stamp, which, after considerable searching and fumbling in a bureau drawer, was produced with the remark:

"I have had them two years, but I hever sold one before."

Two letters lay upon the table, and we added a third to swell the outgoing mail. Leaving, as we had entered, through the kitchen, we rejoined the party under the grove of mighty pines, and resumed our light-hearted journey westward.[74] It was almost dark when we pulled up at "Jam One," on the

[73]Oscar L. Giddings became the first postmaster of Fletcher in August of 1883, two months before he was one of the organizers of Glade Township (see also note 69). The *Tribune* reporter was likewise impressed with his search for stamps, although indicating that more mail was dispatched than simply Bailey's letter:

"'I don't jest know where they be now, I swan,' said a backwoods postmaster Monday morning in reply to the demand of the Agricultural college expeditionists, for stamps. The professors and students had halted on seeing the sign of 'Post Office' on an old log-house at one of the corners of their dusty road to Fife Lake, and were assembled in the little, low room which served the double purpose of an office and dining room for Uncle Sam's servant. The grey-haired postmaster, who was also a farmer, was looking for the stamps.

"'I swan, I don't know where they be. Maria, Maria, do ye know whar I put them stamps?' And with the help of his spouse the necessary articles were unearthed from the bureau drawer, and Profs. Beal, Bailey and Wheeler posted their letters for anxious ones at home, and Students Pelton and Dewey handed over letters for their sweethearts, which they had been carefully preparing for three days previous."

[74]Only one specimen, *Rosa acicularis,* seems to have been collected at "Fletcher's"; it is labeled Crawford County but dated June 18. Four additional collections are labeled

picturesque Manistee, and pitched our tent where the gurgling water and the calls of whip-poor-wills added a charm of life to a wild scene.[75] Here we found a settler, Mr. Calkins, the only one in the whole township, if we except the hordes of bloodthirsty mosquitoes which gathered in companies and battalions about our heads. The Upper Manistee is a wild and picturesque stream, and the view from our little camp, comprising the rapid river in spirited curves and the picturesque spires of cedar, was worthy the study of any artist. A zest of adventure was added to the scene by a company of river men, uncouthly dressed in various colors and swaggering in lawless ways, who lay before our fire of pine knots. These men are characteristic of the place and occupation. Rough, brawling, but withal generous, they are unique in the industries of the woods. Your correspondent visited their camp at night, a low and old log cabin, barn-like and unkempt in the interior, the "boys" sleeping in rude board bunks on beds of hay. They live in the most primitive fashion, and at night amuse themselves with songs and stories.

L.H.B.

[June 23, 1888, page 7]

STILL IN THE FOREST.

A Storm in the Woods—An Interesting Narrative of the Trip.

FIFE LAKE, GRAND TRAVERSE CO., June 20.—[Special.]—The first flush of morning brought an army of mosquitoes to the ears of the dreamers who slept Monday night on the banks of the Upper Manistee. There was no promise of relief from negotiation or arbitration. There was no alternative but an unconditional surrender. This accounts for the unseasonable breakfast eaten by the exploring party and the early departure from a place full of natural beauty. The Upper Manistee is a beautiful stream, set in a picturesque region, rushing and gurgling in a serpentine course. "Jam One," the scene of the present camp, lies in a spirited picture of high and low banks, old and mossy cedars and a musical stretch of river. When twilight had settled over the travelers, the low murmur of the waters below the tent reminded one of the soft call of the

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only "Glade" but attributed to Kalkaska County, June 18: *Krigia biflora, Panicum columbianum, P. depauperatum,* and *Poa pratensis.* Beal & Wheeler (1892, no. 119) cited *Viola lanceolata* from Glade Tp.

[75]Jam One was the name which resulted from a tremendous log jam where the North Branch of the Manistee River flows into the Manistee itself. Big Cannon Creek empties into the Manistee almost opposite the North Branch, and it was on the west bank of this creek that David C. Calkins settled in 1883. When the post office was opened in 1891, the government would not accept "Jam One" and the name was changed to Sharon. (See McCann, 1972, pp. 2-12, "A Brief History of Sharon.")

Despite the aggressive mosquitoes, several collections were made here June 18 and 19: *Carex aenea* (108; "Near Fife Lake" but Bailey's List says for this number "Jam One. June 17"; the specimen is dated June 18), *C. oligosperma* (107; "Near Fife Lake" but Bailey's List says for this number "Jam One. June 17"; the specimen is dated June 19, and the species would certainly be more likely in the bog visited closer to Fife Lake on the 19th), *C. rostrata* ("Jam I Bridge on Manistee R."), *Dryopteris phegopteris* ("Near Jam One Bridge"), *Lonicera dioica* ("Calkins, on the Manistee R."; date of 6-20-88 clearly wrong), *L. hirsuta* ("Calkins").

cuckoo, and more than once a tired head was raised in the dim light of the camp fire to make sure that a belated bird was not calling in the stillness of the night. Gradually the shrill hum of musquitoes ceased, the fire burned low to a few glowing coals and primeval silence settled over nature like a great blanket. One by one the campers, wrapped in woolen blankets, dozed into forgetfulness, only to be awakened by the serenade of the diligent musquito. A misty hour of the early morning was devoted to the festive graylings which shaded themselves in the clear shadows of a little brook, which joined the river in the rear of the camp. Grayling were eaten at supper and grayling were eaten at breakfast, but grayling scorned the acquaintance of the members of this energetic expedition.[76] It is only the plethoric fisherman who is content to sit astride a log roasting the back of his neck in the fervent June sun while he leisurly showers tobacco smoke at the envious musquito, who can court the favor of this game fish. And even then the blanks are numerous and painful.

"Jam One" is a crooked place in the Manistee, where logs are apt to pile up in great numbers, as it is the first place from the source where great stoppages occur. It is designated "Jam One" or more commonly "Jam One Bridge." The bridge is about three-fourths of a mile below Calking's [sic] Clearing where the party camped. The jam is a favorite place for grayling fishing, especially among residents in the western portion of the State.

Westward from the Manistee the country assumes a different character.[77] Better land, more hard wood and occasional and prosperous farms give an attractive appearance to the country. The region is good farming land, the soil being sandy but abounding in vegetable matter. The forests are exceedingly dense and green and the undergrowth is luxuriant. The prevailing timber is hard maple, beech, elm and hemlock, just the admixture which indicates early and

[76]It would not be clear from this ambiguous sentence whether the party ate any grayling, though they failed to catch any. Perhaps the local lumbermen supplied some, for the *Tribune*, in a similarly ambiguous passage, says: "In return for the visit the lumbermen explained to the professors the mysteries of grayling fishing and insisted on showing them the best place to catch that gamey swimmer the next morning. The grayling were caught, however, and the journey of Tuesday was undertaken on a breakfast of dried beef and coffee." But L. H. Dewey (in Beal, 1889, p. 187) is clear: "The Au Sable and the Manistee are both grayling streams. The grayling is a small fish something the shape of a perch, and is very fastidious in its habits. It will not remain in dirty water. For this reason we did not see any in the Au Sable, which was kept muddy in all parts by the driving of logs. The water was clearer in the upper Manistee, and the first night that we camped on this river, we had grayling for both supper and breakfast. It makes a very good dish, but it is probably its rarity and its gamy habits on the hook that give it such a great reputation." The famous and now extinct Michigan grayling, for which the county seat of Crawford was renamed, was already disappearing from the Au Sable around 1890 and did not remain common much longer in the Manistee. (See Miller, 1963, pp. 85-112; Hendrickson, 1966, pp. 11-12; Leonard, 1960.)

[77]Jam One was near the northwest corner of T25N, R6W—the township immediately west of Glade (R5W). The next township west (R7W) was Garfield, and while no direct mention of it is made in the reports, several specimens were collected June 19, the labels giving no locality other than the township: *Adiantum pedatum, Cirsium arvense, Epilobium glandulosum* (sens. lat.), *Geranium bicknellii,* and *Puccinellia pallida.* All were presumably collected near the road, which went straight across the township one mile south of its northern edge.

rich land. The swamps are filled with cedar and spruce, some of the former attaining great size. One tree was seen which measured over three feet in diameter. This cedar is the plant commonly known as arbor vitae in cultivated grounds, the same as that used for telephone poles. Botanically it is not a cedar, nor yet a white cedar, as it is commonly called, although it is closely akin to the true cedars, plants which are represented in Michigan by the common red cedar.

In the western portion of Kalkaska County the wild black raspberry was first seen. It had not been found upon the Huron shore nor upon the plains, although diligent search had been made for it. Its presence indicates a more southern cast to the region, a feature corroborated by the occurrence of other plants of a more southern range. Coming into the more settled portions of the county near Fife Lake apple trees in health and vigor were seen, and the few farms gave evidence of more intelligent management. The wild fruits of any region are an important indication of its horticultural possibilities. The wild grape is almost entirely absent from this tier of counties, the party having encountered it but two or three times during the whole journey. Even when found it grew among undergrowth where it was much protected, and it did not appear to fruit profusely. We should expect, therefore, that the garden grape, which has [sic] from a native species closely allied to this seedling, can be grown only by protection. This protection is readily afforded, however, by laying the vines down in the fall, an operation practiced extensively in many more southern latitudes. Near Fife Lake a few cultivated vines were seen in a vigorous condition. The wild crabapple has not been found. It is usually observed that the culture of the common varieties of apples do not extend much beyond the range of the wild crab; but there is every reason to believe that many of the very hardy varieties may be safely planted here. The few trees now growing in this region appears [sic] to represent such varieties largely, the Ben Davis being prominent. Yellow, transparent, Oldenburgh, Whitney, seek-no-further and the improved crabs are to be recommended for this region. The wild blackberry is everywhere abundant between the two lakes, growing alike upon the plains and timbered lands. The wild red raspberry is frequent throughout. The presence of these species is indication enough that the country possesses possibilities in small fruit growing. It is commonly observed, however, that the cultivated raspberry and blackberry are injured by cold when the wild bushes in the immediate vicinity pass the winter in safety. The reasons for this are chiefly two. In the first place the natural protectors of the plants, the forests and wild bushes, are destroyed. The wind sweeps over the country with fury, driving the snow before it, and exposing plants to great vicissitudes of weather. If Upper Michigan is to become a prosperous farming country natural windbreaks must be preserved. The second reason for the more frequent injury to the cultivated plants is the fact that cultivation, unless properly pursued, causes a vigorous and somewhat softer growth which is unable to endure great extremes of climate. Wherever the soil is strong enough, currants and gooseberries will thrive. Two or three very small plantings of currants have been seen, and they are uniformly vigorous. In fact the wild red currant is common in the swamps, and other wild species occur. The wild gooseberry is also often seen. The wild plum is found at Mio and other places in Oscoda County, and a critical search would undoubtedly reveal it in other places. Both the red and yellow varieties occur near Mio. At Coming's [sic] Opening, on the Au Sable, a few wild plums had been transplanted. The common wild plum is exceedingly variable, and it is now being introduced into cultivation very largely. Many improved varieties are largely cultivated. All these will undoubtedly prove hardy and valuable here in this northern country. The sand or dwarf cherry grows abundantly upon the poorest plains. Its fruit is variable, but usually as large as a small grape. In flavor it is good to excellent. The plant is a low and straggling bush, seldom growing over five or six feet high. It is a profuse and reliable bearer. It requires no scientific training to predict that this plant has a wonderful future before it. If the few inhabitants of the plains had even a moiety of energy and a whit of observation this wild cherry would be found growing in every garden. At present even the garden is usually missing. If the inhabitants want anything in the line of fruit they will have the old varieties of more favored latitudes or they will have none. The sand cherry, it is admitted, is not a Governor Wood nor a black heart, but it is good and wholesome, and is capable of great improvement. It thrives in the poorest and driest sand, and is not injured by any extreme of climate. Its possibilities for the plains are great. Another promising plant of the plains is the wild dwarf service-berry or June-berry. The fruit closely resembles a huckleberry, and the plant is often sold for such by ignorant and unprincipled nurserymen. The bush is comely and attractive, growing from four to eight feet high. Of late years it has been introduced into cultivation. As soon as its merits are better known, its culture will become common in all cold climates. Three species of huckleberries, closely following each other in periods of ripening, are everywhere exceedingly abundant on the plains. As soon as markets become more accessible there is no doubt that these berries will become a profitable crop on the barrens. It will be only necessary to inclose the land and to remove other vegetation in order to grow them with profit. On the whole, the horticultural outlook is more encouraging for our barren plains than for the rich prairies of many parts of the Northwest; an outlook, however, which depends upon the hope that the country will never be denuded of all its forests.

The lumbering interests are waning. The logs which are now coming down the rivers are poorer in quality, as a whole, than those sent down in former years. Most of the best timber has been cut off, although there are still whole townships together bearing primeval forests, majestic and dark. The modern methods of lumbering decimate the great forests with astonishing rapidity. The old time methods, which were employed chiefly in winter, are superceded [sic] by the giant wheels, the steam tugs and the railroads, which make lumbering more satisfactory in summer than in winter.[78] In the midst of virgin forests the

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[78]Narrow-gauge logging railroads were comparatively new at the time, and indeed had revolutionized the industry by making rapid transport of logs possible in summer, without dependence on ready access to streams or on the freezes of winter for skidding and sleighing. Winfield Scott Gerrish is widely credited with building the first successful railroad in the United States to be used exclusively for logging. This was the Lake George and Muskegon River Railroad, built in Clare County, Michigan, the winter of 1876-1877. Gerrish's great success led to the operation of 89 logging railroads in Michigan by 1889 (Maybee, 1959, p. 420; Catton, 1972, p. 114, says 49 lines for the same date, "by 1889,"

traveler comes suddenly upon a well built railroad, and presently an engine rolls by at a thundering pace dragging a giant train of logs or rather trees. These logs are usually the full length of the tree, hoisted upon the peculiar trucks by steam or horse power, and are sawed into lengths when placed upon the lake or river previous to being sent crashing down the "roll way" into the water. Many of these railways are narrow gauge. Few of them connect with any passenger road. They are temporary affairs, although built with great strength and care. They are moved from place to place as fast as the timber is removed from their vicinity. They always terminate in a lake or river, where the logs are dumped and floated down to the great saw mills. In some cases these loads of huge logs are shipped to their destination on cars. This is true to a considerable extent upon the Detroit, Bay City & Alpena Road, from Gen. Alger's forests. From the woods to the railroad or the water the logs are drawn by horses upon "wheels." These "wheels," as technically known in the lumber woods, are huge contrivances consisting of two wheels from nine to fourteen feet in diameter, turning upon an axle a foot in diameter. Great logs sixty and seventy feet long, four to eight in number, are dexterously balanced under these spider-like wheels, and are drawn by one span of horses. To the ordinary farmer the amount of timber which one team will handle easily is almost beyond belief. A team will draw logs which will scale a thousand feet. This is rendered possible by the most thorough application of mechanical principles. The trimmings of the trees are left where they fall, and all small and inferior timber is left untouched only as it is broken by the falling of the great pines. When the pine is removed, the region presents a dismal appearance. The harmony of nature is broken, and a jarring scene makes the country forbidding. The brush and discarded logs soon become dry, the pitch oozes out in the broiling suns, and the first spark sets the forest afire. Then every green thing is burned, the vegetable matter is licked out of the soil, and the work of ages is undone. But the fire does not stop with the slashings. It spreads into untouched forests of pine, and often leaves only a barren forest of stubs. In the hardwood lands, where pitch does not occur and where the undergrowth is more umbrageous, forest fires seldom do great damage.

The whole business of lumbering impresses one as exceedingly slovenly. Every move of the ordinary lumberman proves that his desire is to skin the country, to pocket the "almighty dollar," irrespective of the ultimate and permanent damage wrought to the country. Your reporter, for one, can entertain little respect for the man who buys his land solely for the timber it contains, slashes off the forest in the most reckless manner, and then allows the denuded and devastated land to revert to the State. He has seen many lands for which lumbermen paid $100 and more per acre, it is said, but which are now in the general market for $5 and less per acre, and yet they are lands which once contained sufficient fertility to render them valuable for agricultural purposes.

Tuesday afternoon the expedition passed through an inviting country east

but this seems an understatement; Poor's Manual [1889, pp. 26-29 of Appendix] lists 73 private lumber or logging railroads, not common carriers, for Michigan as of 1888). (See Maybee, 1959, pp. 417-422 [1960, pp. 37-43]; Fitzmaurice, 1889, p. 68; Catton, 1972, pp. 113-116.) Fig. 11 shows a narrow-gauge locomotive probably seen in service by the 1888 expedition.

of Fife Lake. Occasional swamps relieved the monotony and afforded the botanists an opportunity to plunge earwards into mud and mosquitos. But the swamps yielded rich harvests. One bog presented in abundance one of the most beautiful and rarest of wild orchids, the little Arethusa.[79] Everyone could see beauty in

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[79]At least two roads came from the east into Fife Lake, one of them continuing the straight road across Garfield Tp. However, the description later in this paragraph of the winding nature of the one taken, together with mention of the bogs and swamps avoidance of which to this day gives the alternative route the appearance of winding, suggest clearly that the expedition turned south for one mile at the site of Deibert (traveling between secs. 11 & 12, T25N, R8W) and then went west to Fife Lake. At the southwest corner of sec. 12, the road curves around what later maps name as Woodard Lake, easily visible from the road, and surrounded by a good bog mat. On June 15, 1975, we found here *Arethusa bulbosa* and some of the other bog species collected by the 1888 party, and we believe this was the bog which was presumably their last collecting site before the storm overtook them and they hastened on to Fife Lake (barely into Grand Traverse Co.).

The *Tribune* account, published June 22, does not mention the bog, but only the storm: "The little prairie schooner, in which both baggage and men were packed, was several times nearly wrecked by falling trees. The rain came down in floods and lightning struck near by in the wilderness. Driver Metcalf's dog, which had been foolish enough to follow the party from his master's home at Grayling, struggled on behind, frequently having to swim through the lower places. Not one of the professors had ever seen anything like this storm and every one in the party was drenched to the skin. Fife Lake and its hotel were hailed with relief."

We have no idea where the party had dinner (the mid-day meal) between Jam One and Fife Lake, nor what they did during the morning. We only know of the severe storm, which both newspaper accounts agree was in the afternoon, and the threat of which caused them to leave the *Arethusa* bog—evidently one of several damp places visited in the afternoon (according to Bailey in the *Free Press*). Since the storm lasted two hours and Fife Lake is scarcely a mile into Grand Traverse County, we assume that any specimens labeled as coming from east of Fife Lake, as well as any bog species merely labeled Fife Lake but dated June 19, must have been collected in Kalkaska County. Labels on the following collections cite Kalkaska County and June 19 when not otherwise indicated: *Alopecurus aequalis* ("Fife Lake" 6-20), *Andromeda glaucophylla* ("Fife Lake. Gr. Traverse Co."), *Arethusa bulbosa* ("In open sphagnum swamp with Kalmia, on edge of a small lake east of Fife Lake" MSC; "Near Fife Lake"—no county stated, BH), *Calla palustris* ("In sphagnum on an overgrown lake, east of Fife Lake"), *Carex atlantica* var. *incomperta* ("Near Fife Lake"—no county stated), *C. chordorrhiza* ("Fife Lake" 6-16), *C. prairea* ("Near Fife Lake"—no county stated, June 20), *C. tenuiflora* ("Near Fife Lake"—no county stated, June 18, BH; "Near Fife Lake," MSC—but with no. 85 of Bailey's List, referring to the same species from Frazer's), *Equisetum fluviatile* ("Fife Lake. Gr. Traverse Co."), *Eriophorum gracile* ("Fife Lake, Gr. Traverse Co."), *Habenaria dilatata-hyperborea* complex ("Abundant in swamps of Northern Mich. Fife Lake"), *Hydrophyllum appendiculatum* ("Fife Lake" 6-20), *Vaccinium oxycoccos* ("Near Fife Lake"—no county stated). The *Hydrophyllum* specimen is labeled "Kalkaska Co." even though dated June 20; another non-bog species, *Helianthemum canadense* ("Open sandy plains. Fife Lake") is also dated June 20, and has no county indicated—conceivably it could have been collected the morning of June 20 in Grand Traverse County as the party left Fife Lake. Many of these collections (all those from "Near Fife Lake") were made by Bailey (in BH) and tend to be confused as to date; between the storm and his impending departure at Fife Lake, Bailey must have had other things on his mind. Of the species listed here, we collected the following during a brief period in the bog at Woodard Lake June 15, 1975: *Andromeda glaucophylla, Arethusa bulbosa, Carex atlantica, Equisetum fluviatile, Eriophorum gracile, Vaccinium oxycoccos;* also *Kalmia*, mentioned on an *Arethusa* label, and *Carex oligosperma* (see note 75). We collected 10 species of *Carex* but saw none of the others listed above. The thrill of finding this *Arethusa* bog brought joy to an otherwise gloomy, rainy day for our party and we, too, arrived "wet but happy" at Fife Lake.

this shy flower, and could feel something of the tingle of excitement and adventure which appeared to overtake the botanists at regular intervals. From this swamp the explorers were warned to fly by the appearing of dark clouds in the east and mutterings of distant thunder. The roll of the thunder became more distinct, lightning played vividly in the massive clouds and the wind moaned through the tree tops. The party hastened on and were soon buried in a dense wood, through which the road wound in and out, up and down, in a veritable labyrinth. A heavy gloom enveloped the forest. The silence which precedes a great storm rested over nature. Presently the storm broke in wild fury, the wind raged through the trees, driving the rain in blinding sheets. It was a terrific storm. The trees swayed and creaked and limbs fell on every side, and trees fell across the track. For nearly two hours the storm continued. Water ran in torrents down every incline and collected in great ponds in the hollows. It ran in trickling streams down the spinal columns of the botanists, and filled their shoes. It ran sideways, upwards, obliquely, wetting drying papers, provisions, clothing, and everything save a lone reporter who curled himself up like a woodchuck under a rubber blanket. Wet, but happy, the party arrived at Fife Lake for supper.[80]

Fife Lake is a characteristic town of the older lumbering regions. Once it was vigorous with the teaming [sic] life brought in by great mills and other lumbering interests. Now it is dead, a relic of former activity. Deserted houses and the remains of mills testify to its departed glory. The agricultural features of the surrounding country have not been largely developed. The same future appears to await most of the thriving towns of Upper Michigan.[81]

L.H.B.

[June 26, 1888, page 8]

AT AN END.

The Exploring Trip of the Agricultural College People.

FRANKFORT, June 25.—The long journey across the State is at last at an end. Wednesday morning after the storm of the previous afternoon the party collected again the numerous packages and camp equipage, loaded them into the big white schooner and proceeded on their journey. Prof. L. H. Bailey was left at

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[80] If Bailey alone remained dry (beneath the rubber blanket for his camera?), the fact escaped the notice of the *Tribune* reporter (quoted in second paragraph of previous note). No mention is made of camping for the night, and we assume that the party patronized the hotel which was "hailed with relief." Presumably there were wet specimens and presses to take care of, although it is interesting that the newspaper accounts never refer to the tedium of pressing, drying blotters, etc.

[81] Fife Lake and North Fife Lake were platted a few months before the Grand Rapids & Indiana Railroad reached the lake, in 1872, but were incorporated as a single village in 1889. From an estimated population of 1200 in 1884, it fell to 700 in 1888 and 450 in 1890. The lake itself was named in 1867 for William H. Fife, of East Bay Township, Grand Traverse County, Commissioner of the Traverse Bay & Houghton Lake State Road then being surveyed (but which was never built). (See Page, 1884, pp. 84-86; Polk; Barnes, 1959, pp. 69-72.)

Fife Lake, and the party, now reduced to five, continued on.[82] The sky was clear after the storm and the sun poured down its tropic heat even in the early morning. The wagon turned toward the west and slowly crawled up the steep sand hill to leave the town. Once at the top and the same dreary waste stretched out before. The plain denuded of trees with burned stubs pointing warningly upwards was uninviting in the extreme. Yet even here flowers and plants before unfound on the waste were discovered. After several miles had thus been traversed the cool woods of mixed timber showed itself in the distance. The shade is very refreshing now as the morning is well advanced and old Sol is getting in his work with great vigor.

Dr. Beal sighted a large dead tree and called a halt. On examination the tree showed some very fine work of the large red-headed woodpecker, or log-cock. The Doctor looked over the specimen very carefully, estimated the weight and room it would take up in the wagon, then looked down and thought of the possible discomfort. Driver Metcalf saw his opportunity for another fee, and a bargain was soon made by which the specimen will be secured on his return trip. Metcalf wore a very complaisant expression as he returned to the wagon with the remark, "That with the beaver gnawings, the bear scratches and the corner mark makes eight old shiners for the return trip."

The country now became very rough and uneven; steep sand hills and sand plains made progress very slow, and it was late noon when the party halted at a forlorn looking hotel at Kingsley.[83]

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[82]The *Tribune* reporter said: "Prof. Beal decided that it would not pay to visit his experiment farm at Walton [ca. 4 mi. SW of Fife Lake], and with the exception of Prof. Bailey, who has been obliged to return to Lansing on business, the party will continue their journey to the Lake Michigan shore." There are no more reports in the *Tribune*, so perhaps Mr. Parish also returned home from Fife Lake. Neither paper indicates exactly why Bailey cut short his trip, but the Lansing *State Republican* for June 22 is clear: "Prof. L. H. Bailey left for Cornell University this morning, where he will remain several days making arrangements for his work which begins there in September." Bailey returned to Lansing June 25.

This last dispatch in the *Free Press* is anonymous, but from the light way in which Wheeler is mentioned we suspect that he himself wrote it.

[83]Two roads from Fife Lake to Kingsley were available at the time; we assume the expedition took the northern one up the hill at North Fife Lake, west to the present route of highway M-113, rather than a parallel one a mile to the south, which would have meant turning north for a mile into Kingsley.

Judson W. Kingsley came from Illinois in 1865 and homesteaded in sec. 8, T25N, R10W–organized in 1870 as Paradise Township. When the Traverse City Railroad (later a division of the G. R. & I.) was built in 1872, "Kingsley" was one of its stations and trading began to grow rapidly. In 1873, Mr. Kingsley became postmaster of the adjacent community of Paradise (named for the township), which was formally platted in 1882. In the same year, the post office was renamed Kingsley, and in 1890 both plats were incorporated as the village of Kingsley. (See Page, 1884, pp. 88-89; Romig, 1972, p. 305.) The population of Kingsley was estimated at 150 in 1887, 700 in 1889, and 450 in 1891 (Polk); the expedition must have seen the town at its peak.

The following plants were collected June 20 at Kingsley (or locality as noted): *Carex flava* ("Paradise"), *C. tuckermannii, Comptonia peregrina, Potamogeton gramineus, Pyrola elliptica* ("Near Paradise" BH; "Paradise Tp." MSC), *Stellaria longifolia, Viburnum cassinoides* ("Paradise Tp."), *Viola renifolia* ("Paradise").

Fig. 14. A white-cedar (*Thuja occidentalis*) 52 inches in diameter, west of Kingsley, Grand Traverse Co., June 20, 1888. W. J. Beal, in straw hat, stands below toward left. (Photo not by Bailey, who had left the expedition at Fife Lake; from M.S.U. Archives & Historical Collections.)

Kingley [sic] is a village of perhaps 500 inhabitants, situated on the Grand Rapids and Indiana Railroad, having all the characteristics of a used-to-be lumbering town. There is considerable hard wood in the vicinity which is lumbered to some extent yet.

In the afternoon the course ran through a better country than had been seen before on the trip.[84] Although the soil is still sandy there is sufficient clay and vegetable mold incorporated in it to give it subsistance. The timber is heavy beech, maple, birch and hemlock, with some pine. The land is cleared and productive farms are more frequently seen. Through the deep valleys, too, trickling brooks filled with spotted trout run merrily along and are a feature distinctive of the western part of the State. Late in the afternoon the party passed

[84]A very large white-cedar seen west of Kingsley in shown in Fig. 14; it is mentioned by Beal in Beal & Garfield (1888, pp. 29-30), along with some other large trees probably noted on the 1888 expedition: white pines 162 and 195 inches in circumference, in Kalkaska Co.; a white pine at 282 inches and an American elm at 84 inches said to be near Fife Lake; a pin cherry 40 inches in girth at Frankfort; an ironwood with a diameter of 12 inches, a yellow birch 142 inches in circumference, and a sugar maple 120 inches in circumference, at Garfield [Tp.], Grand Traverse Co.; and on "the upper Manistee, at Aurora Frazer's [a contradictory locality!], we measured [a jack pine] two feet above the ground that was four feet eight inches around, and another four feet and nine inches."

through the Township of Mayfield, Grand Traverse Co.,[85] where they saw the finest farming country that has been seen. It has been long enough settled so that the fields are cleared of stumps, and excellent crops are everywhere to be seen. Fine fields of wheat and rye are just coming into blossom, clover grasses are thick in the meadows and give promise of an abundant crop of hay. Not only do the fields and crops show an abundant evidence of thrift but the houses and buildings likewise attest the general productiveness of the soil. Large, well-painted and elegant farm houses are the rule, with barns and commodious stock sheds to correspond. The influence of the lake is felt here and no doubt fine fruits can be raised. Large orchards are not uncommon and young trees look thrifty. Land here uncleared but back somewhat from the road sells for from $5 to $10 per acre, and some good pieces may be bought for less. Why should people go West for good farms? Dewey remarked that this soil needs no experimental farms.

We turned north here, and fourteen miles from Traverse City we came to the brow of a hill where was seen one of the most beautiful views in the State.[86] A deep, wide valley below with cleared fields and farm houses, while over the tops of the trees which filled the view beyond were the rolling knobs of high, green hills which make the lake ridges along the shore.

Descending into the valley, a hospitable farmer received the party for supper and they camped for the night.[87]

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[85]Since Mayfield Township (T25N, R11W) began only two miles west of Kingsley—where the party evidently had a mid-day dinner at the "forlorn looking hotel"—it is not clear why it was "late in the afternoon" before they passed through. Specimens collected in Mayfield Tp. June 20 all seem to be labeled without contradictions: *Carex diandra, Corallorhiza trifida, Eleocharis smallii, Iris virginica* var. *shrevei.*

Specimens collected June 20 with no locality indicated except the county may have come from Mayfield Tp. or elsewhere along that day's route: *Carex paupercula, C. rostrata* (perhaps at campsite in Green Lake Tp.?—see note 87), *Veronica arvensis.* A specimen of *Ribes americanum* labeled by Bailey (GH) dated June 20 and with C. F. Wheeler given as collector has only "Kalkaska Co."—which the party had left on June 19; this specimen was probably among those supplied (by Wheeler?) to Bailey after the latter left the expedition at Fife Lake and came, then, from Grand Traverse Co.

[86]It is not obvious from the account where the expedition turned north. "Here" seems to refer generally to Mayfield Township. Probably the party continued due west from Kingsley (present route of highway M-113) to the west edge of the township (i.e., two miles west of the present highway M-37) before turning north. A road on the present line of M-37 was also available, two miles to the east; but the older, western one was a state road and stage route following the rangeline, and this would explain the specimens collected both June 20 and June 21 in the next township west (see next note). No mention, however, is made here of passing through Monroe Center (which was settled in 1859 and given a post office in 1866); a half mile north of that community the road comes to the edge of the Port Huron Moraine at a point about 150 feet above the valley to the north—surely the view acclaimed in the newspaper account, although closer to 10 than 14 miles from Traverse City.

[87]Lynn Rayle (pers. comm., 1975), to whom we are indebted for many helpful suggestions regarding the route through Grand Traverse and Benzie counties, indicates that after going down the hill past Monroe Center, the first farm the travelers would have encountered would probably have been the A. J. Curtiss farm on the S½SE¼ sec. 13, T26N, R12W (Green Lake Tp.). Specimens collected June 20 in Green Lake Tp. would then have come from the west side of the road anywhere from 1 mile south of Monroe Center to the

Early next morning the line of march was again resumed.[88] The soil here is poorer and more marshy and supports more pine timber. The journey of the day was quite uneventful until nearly noon. The sun was approaching the zenith and the party were all looking with longing eyes and appetites for some place for dinner when emerging from the thick woods we saw stretching out before us a desolate, burned district as far as eye could see. Thickly studding the plains were the straight, dry stubs of half burned and dead pines. Mile after mile of this was passed and even Wheeler began to betray himself by expressions suggestive of dinner. At last a clearing loomed up in front and a solitary log hut with a large sign, "The Central House."[89] We were taken in and fed, and Wheeler regaled his dyspeptic stomach with fried pork, potatoes, etc. The road for the afternoon laid

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presumed campsite 2 miles north of Monroe Center: *Calamagrostis canadensis, Carex aurea, C. pseudo-cyperus, Habenaria hyperborea, Phalaris arundinacea, Rorippa palustris.* (On June 16, 1975, we found the *Rorippa* and abundant *Phalaris* in a marshy hollow near the SE corner of sec. 13, and also *Sagittaria* sp. [see June 21 list, following] and *Carex rostrata* [see end of note 85]. Specimens attributed to Green Lake Tp. the next day, June 21, may have come from the campsite or anywhere else along the route (see next note) before entering Benzie County: *Arenaria stricta, Cypripedium acaule* ("Large leaves common in the plants found in the pine woods"; no locality other than county given, but Green Lake Tp. was the only one traversed on June 21), *Galium triflorum, Geranium pusillum* ("From cult. Near where a settler's log house had burned."–see Fig. 2), *Poa alsodes, Potentilla argentea, Sagittaria* sp., *Veronica americana.*

[88]Once again, the brevity of this last dispatch gives no evidence as to the route across Green Lake Tp. to the adjoining Inland Tp. of Benzie Co. Probably the wagon turned west in the north half of sec. 13 and in two miles joined the present route of highway U.S. 31, which may have been taken straight west all the way to the county line. Or the party may have turned south through the middle of sec. 16 (where Interlochen was begun the next year, 1889, as the Manistee & Northeastern Railroad was being constructed), thence west a mile south of present U.S. 31.

[89]The Central House is the first definite location cited for Benzie County and helps to establish the route taken. According to the Page map (1884, facing p. 288) it was located at the NW corner of sec. 27, T26N, R13W (Inland Tp.). Our retracing of the route revealed a concrete foundation with rotting log subfloor beams, which we would like to think represented the remains of the Central House, in a grove of very large trees at the adjacent NE corner of sec. 28. Regardless of the precise spot, it is clear what road the expedition was following at the time, and it was not a more northerly route which the old maps show coming close to the Platte River before turning south to Homestead. In view of the "mile after mile" of desolate country which delayed their dinner, it would appear that the party did not pass through the community of Inland, which had at least one hotel (Polk) and was on the more northern road. Where the expedition turned south from the present route of U.S. 31 we do not know (see preceding note)–whether on the county line or in Grand Traverse County.

Specimens labeled from Inland Tp. (or merely "Inland" after the custom of the times), June 21, are as follows: *Acer rubrum, Chrysosplenium americanum, Habenaria dilatata*, Listera convallarioides*, Milium effusum, Myrica gale, Poa pratensis, P. saltuensis* (cited, as *P. alsodes,* from "Inland, Grand Traverse Co." by Beal & Wheeler, 1892, no. 1622–there was evidently uncertainty as to the location of Inland), *Ranunculus recurvatus, Rubus* sp. ("Variegated"; originally labeled *R. villosus,* which Beal & Wheeler, 1892, no. 307, said covers "thousands of acres of waste pine-land to the exclusion of almost everything else."), *Scirpus acutus*, Smilax tamnoides* var. *hispida, Vaccinium oxycoccos*, Veronica serpyllifolia.* The four species marked with an asterisk are represented by specimens in two herbaria, MSC and BH, those in the latter set matching well the former, but the labels all attributing the collections to Beal, June 21, and "Gd. Traverse Co."; we

[sic] through a beautiful country, uneven but fairly fertile.[90] At evening Benzonia was reached after climbing a mountain-like hill, on the top of which the village stands.

Benzonia College, now changed to Grand Traverse College, was the first building to attract our attention. The old college building has been burned and the college now is removed to a building formerly used for a hotel.[91] Although there are few students at present the trustees have great hope for their college when the county becomes more thickly inhabited. The air of the founders of the college still lingers in the place and Oberlin like, many adhere to the old doctrines.

The party camped for the night on the shores of Crystal Lake,[92] a beautiful body of water nine miles long and three wide and extending to within a mile and a half of Frankfort. In the morning Frankfort was reached before breakfast and we were at last across the State. Friday was spent in exploring along the shore and in examining the sand dunes along the lake.[93] Many rare species of

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assume that these are duplicates of the Inland Tp., Benzie Co., collections in MSC (see p. 13). The *Listera* was cited by Beal (1899, p. 181).

Beal (1889, p. 180) listed *Marrubium vulgare* from Grand Traverse and Benzie counties, presumably as a result of this trip, but we have been unable to locate any supporting specimens. Beal & Wheeler (1892, no. 1695) list *Thelypteris phegopteris* (as *Phegopteris polypodioides*) from "Inland, Grand Traverse Co." but we have found no specimens either for Benzie or Grand Traverse county.

[90]During the afternoon, the party crossed Homestead Tp. (T26N, R14W, between Inland and Benzonia Tps.). Oddly enough, all but one of the specimens labeled from Homestead are impossibly dated June 22 rather than June 21: *Lactuca canadensis, Polygonum cilinode, Sparganium minimum* (BH sheet labeled June 22, "Gd. Traverse Co." and attributed to Wheeler; presumably it is a duplicate of MSC sheet labeled Homestead and correctly attributed to Benzie Co., June 21; Beal, 1889, p. 180, cited the species from Benzie Co.).

[91]Benzonia, founded by Oberlin College alumni and other Congregationalists, was one of the first settlements in the county (1858), incorporated in 1891. The story of the town and the college, where his father had taught in the 1890's and served as acting president (and later, 1906-1917 as principal of the Academy), are well told by Bruce Catton (1972, especially chapters 2 & 7); the basic facts are in the standard old histories as well (e.g., Page, 1884, pp. 288-292; Powers, 1912, pp. 265 & 361). It is mysterious how this newspaper account written in 1888 could say "Benzonia College, now changed to Grand Traverse College," for the institution was chartered as Grand Traverse College in December of 1862, and began classes in 1863. After a destructive fire in 1874, the college purchased a hotel building, where classes were held. The school was reorganized as Benzonia College in 1891, and in 1900 the institution became Benzonia Academy (which closed in 1918), since Olivet College was flourishing and the Congregationalists did not feel that it was necessary to support two colleges in Michigan.

[92]Collections from Crystal Lake, June 22, could have been made anywhere from near the campsite, which was probably at or near the site of Beulah (see note 94), to Frankfort: *Arabis lyrata, Campanula rotundifolia, Festuca occidentalis* ("Bluff south of Crystal Lake near Benzonia" MSC; "Crystal Lake" GH, labeled by Beal with himself as collector), *Juncus balticus, Juniperus communis, Lathyrus palustris, Lilium philadelphicum, Melica smithii* (see note 94), *Shepherdia canadensis.* Sheets of the *Arabis, Festuca,* and *Melica* also exist labeled Frankfort but these are probably duplicates of the ones labeled Crystal Lake, the exact locality unknown.

[93]Frankfort was settled in the 1850's and the village was incorporated in 1874. It overtook Benzonia in size and importance, and was the largest town through which the

plants were discovered here. On the shore of Crystal Lake, Mr. Dewey found avena smithii, a very rare grass.[94]

The party left Saturday morning for the college, where they arrived at night.[95]

1888 expedition passed, with a population then estimated to be at least 2000, a flourishing harbor served by five steamship lines, and great expectations as the terminus of the Toledo, Ann Arbor & Northern Michigan Railway, due to reach the town in 1889.

Specimens labeled as collected at Frankfort or on dunes north of town, June 22, represent the following species (in addition to those recorded at the end of the previous note): *Agropyron dasystachyum, Anemone multifida, Arctostaphylos uva-ursi, Arenaria stricta, Calamovilfa longifolia* var. *magna* ("Roots form great networks on the sand hills of Lake Michigan shore."), *Carex eburnea, Cirsium pitcheri* ("Rare but quite abundant in the sand dunes on the L. Michigan shore."), *Corallorhiza maculata, C. striata, Dryopteris intermedia, Equisetum pratense* (see p. 14), *Festuca saximontana, Habenaria obtusata, H. viridis* var. *bracteata, Juniperus horizontalis, Lathyrus japonicus, Lilium philadelphicum, Lithospermum caroliniense, Lonicera dioica, Orobanche fasciculata, Prunus pumila, Salix cordata* (labeled "Frankfort. Alcona Co. Mich. 6-22-88"), *Zigadenus glaucus.* Evidently the expedition collected actively just before returning home, even if there seems to have been some lack of distinction between specimens labeled Crystal Lake and those labeled Frankfort.

[94]This grass, now known as *Melica smithii,* was evidently recognized immediately—perhaps because the type locality was in Michigan (Sault Ste. Marie) and it was already known from the state, although not previously from so far south (see Fig. 15 and Voss, 1972, p. 131). Beal (1889, p. 181) declared, "This has been found again . . ." More sheets of this species have been seen in herbaria than of any other collection from the 1888 trip, and the variations on the labels are considerable: "Rare. A few bunches found on a high wooded bluff south of Crystal Lake" (MSC); "Frankfort" (GH, W. J. Beal given as collector and the label in Bailey's hand); "On the top of a high wooded bluff, S. of Crystal Lake" (GH, "Dewey" coll.); "Shore of Crystal Lake" (ILL, GH, both labels in the hand of C. F. Wheeler, the ILL one giving L. H. Dewey as collector). Dewey's discovery here was cited by Beal & Wheeler (1892, no. 1594). How widespread *M. smithii* may be around Crystal Lake we do not know, but on June 16, 1975, we did find it to be locally frequent with *Milium effusum* on deciduous wooded banks in sec. 27 on the west side of Beulah, and the shore here is very likely where camp was made June 21, 1888.

Melica smithii is a western grass, ranging from southern British Columbia and Alberta to Oregon, northern Idaho, and Wyoming. It also occurs in the Black Hills, and in the Great Lakes region (Wisconsin to Ontario). Another of the western disjunct grasses, *Festuca occidentalis,* was also found by the 1888 party in the Crystal Lake-Frankfort area, but they did not recognize it, labeling it as *F. rubra* var. *heterophylla*; it was not reported from Michigan until 1906 (Contr. U.S. Natl. Herb. 10: 25). In Michigan it occurs as far south as Muskegon Co. (Voss, 1972, p. 142); it is also known from the Bruce Peninsula of Ontario but not from the Black Hills, occurring again in the northwestern United States and adjacent Canada.

[95]Since the Ann Arbor Railroad had not yet reached Frankfort, the party must have gone by stage coach or steamer to connect with a train (Flint & Pere Marquette R.R.) at Manistee. The *Free Press* for June 23, in addition to Bailey's lengthy dispatch from Fife Lake, carried a short news item datelined Frankfort, June 22: "Prof. Beal and party arrived here last night and are now botanizing near Crystal Lake. They have found some rare specimens. They leave for Manistee tomorrow." This may have been the basis for the brief item in the Detroit *Evening News* later the same day: "Prof. Beal and his party of scientific friends are reported to have already reached Frankfort. If this be true their trip across the state, through woods and along country roads, must have been fast enough to leave the scientific coat tails flying in shreds."

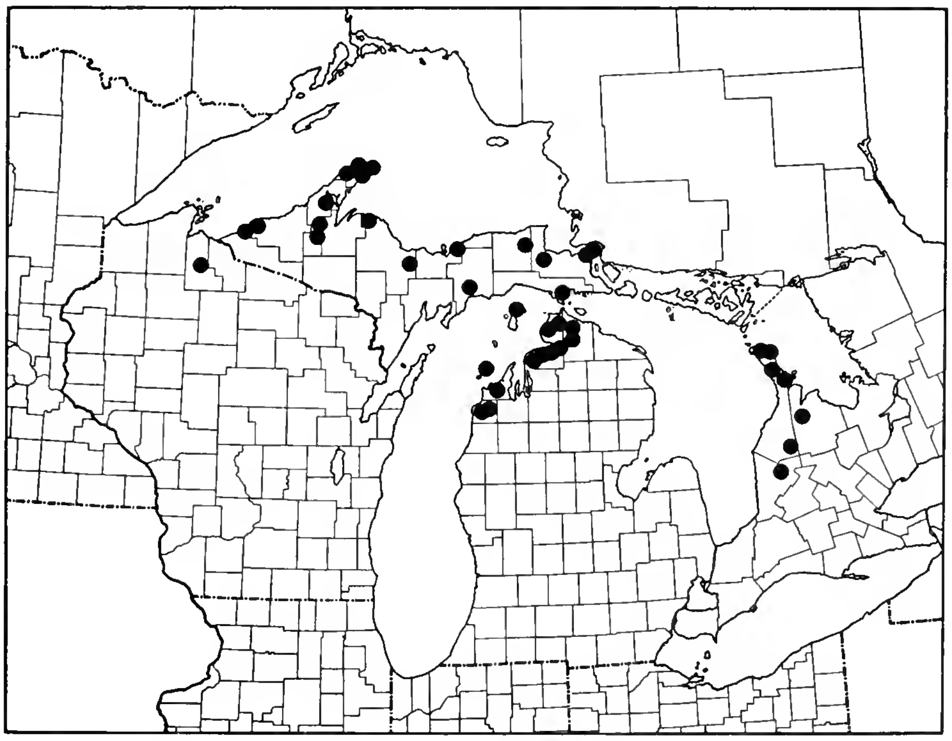

Fig. 15. Distribution of *Melica smithii* in the Great Lakes region, based on herbarium specimens and reliable reports. (Map compiled by Robert J. Marquis.) When it was discovered by L. H. Dewey in Benzie County June 22, 1888, this species was known in Michigan only from the type locality, Sault Ste. Marie, and the Keweenaw Peninsula.

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Fig. 16. Old stage road at crossing of Blockhouse Creek, eastern Oscoda County, June 13, 1975, looking west. The "Block House" in 1888 (see pp. 34-35) stood just to the right on the east side of the Creek. (From a color transparency by G. E. Crow.)

Fig. 17. Jack pine barrens near McKinley (known as Potts Headquarters in 1888–see note 43), Oscoda County, June 13, 1975. Compare Figs. 9 and 13, from Crawford and Kalkaska counties, in 1888. The pine plains have changed but little. (From a color transparency by G. E. Crow.)

Fig. 18 (at left). Old stage road at crossing of the North Branch of the Au Sable River, Crawford County, June 14, 1975, looking west. Frazer's Halfway House was on upland to the right in 1888; *Carex schweinitzii* grows immediately to the left; arrow points to stub of piling from pole bridge which once crossed here (see note 50). (From a color transparency by E. G. Voss.)

Fig. 19 (below). Cheney Road between secs. 16 & 21, T25N, R5W [Glade Tp. in 1888], Kalkaska County, June 15, 1975, looking west. This portion of road is between the sites of Fletcher P.O. and Dempsey's Camp as interpreted in note 69, and probably has changed little since 1888 except for replacement of virgin pines by oak and maple. Compare Fig. 12. (From a color transparency by E. G. Voss.)

Editorial Notes

We hope that this special historical number is a fitting way to open the bicentennial year, and that it does not look too much like an "Annotated Free Press" in the style of such works as the "Annotated Mother Goose"!

GEOBOTANY CONFERENCE: The theme of this year's meeting, which will be held February 21 at Bowling Green State University, will be "Geobotany, an Integrating Experience." For further information, notify Dr. Robert C. Romans, Department of Biological Sciences, BGSU, Bowling Green, Ohio 43403.

BIG TREE NOTE: Since we called attention in the March 1975 issue (p. 82) to the Minnesota big tree list, a new one for that state was published in the March-April issue of *The Minnesota Volunteer.* In addition to the five species previously noted as larger than the Michigan "champions," Minnesota now tops our records for quaking aspen (119 inches) and American or white elm (256 inches).

The October number (Vol. 14, No. 4) was mailed October 9, 1975.

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(On the cover: Members of the Agricultural College expedition across Michigan, at the second night's campsite, West Harrisville [Lincoln], Alcona County, June 12/13, 1888. From left to right: L. H. Dewey, Charles F. Wheeler, W. W. Metcalf, Daniel A. Pelton, unidentified (presumably a newspaper reporter), William J. Beal. Photo by L. H. Bailey, who is therefore not pictured; from M.S.U. Archives & Historical Collections.)

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THE

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March, 1976

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Articles dealing with any phase of botany relating to the Upper Great Lakes Region may be sent to the editor in chief. In preparing manuscripts, authors are requested to follow our style and the suggestions in "Information for Authors" (Vol. 13, p. 190).

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Membership in the Michigan Botanical Club is open to anyone interested in its aims: conservation of all native plants; education of the public to appreciate and preserve plant life; sponsorship of research and publication on the plant life of the State; sponsorship of legislation to promote the preservation of Michigan native flora and to establish suitable sanctuaries and natural areas; and cooperation in programs concerned with the wise use and conservation of all natural resources and scenic features.

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ENVIRONMENTAL IMPLICATIONS OF HIGHWAY DE-ICING AGENTS ON WHITE PINE IN MARQUETTE COUNTY, MICHIGAN

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The distinctive annual die-back of white pine (*Pinus strobus* L.) and other conifers along highways receiving winter de-icing agents has led to public awareness of environmental degradation attributed to salt contamination.

Because of their ice and snow melting ability, cheapness, and ease of procurement, sodium chloride and calcium chloride are the most commonly used winter de-icing agents. Less than one half million tons of these chemicals were used in the United States in 1947 as de-icing agents. By 1970 this amount had increased to nine million tons. During the 1966-1967 de-icing period, those states using the greatest amount of road salt were Minnesota (570,000 tons), New York (680,000 tons), Ohio (740,000 tons), and Pennsylvania (850,000 tons). In that year Michigan distributed approximately 590,000 tons of de-icing agents on its highways (Environmental Protection Agency, 1971). Wind and high-speed traffic cast salt spray on the roadside and adjoining areas. Spring rains wash these chemicals into the soil, ground water, lakes, and streams.

In most areas of the Upper Peninsula of Michigan, public demand has forced a bare-pavement policy for the safety of winter motorists. To meet these requirements, the Marquette County Road Commission operates 12 sand-spreading trucks, 33 snowplows, and 3 snow-goes from their Ishpeming headquarters. To secure bare pavement conditions in a boreal climate in which the snowfall is continuous from November to April, 2,234 tons of sodium chloride (NaCl) and 8,500 yards of calcium chloride ($CaCl_2$) and sand mixture were stockpiled for road de-icing during the 1971-1972 snow period.[2]

Sodium, calcium, and chloride ions have a definite effect on soil properties. Soil particles and chloride ions are both negatively charged. Thus, chloride ions leach into the soil and enter the ground water easily. These chloride ions alter the chemical nature of the soil by adding to the total soil salinity. However, the physical soil characteristics are, generally, not adversely affected.

Sodium and calcium ions are cations and thus are readily adsorbed by soil particles. Sodium replaces calcium on soil particles. As a result, the availability of calcium to plants is reduced. Plants deficient in calcium lack

[1]Present address: 801 Calumet Street, Lake Linden, Michigan.

[2]Personal communication from the Marquette County Road Commission, Ishpeming, Michigan. The difference in substance measurement reflects the way in which they are purchased. However, one yard of calcium chloride and sand mixture is approximately one long ton.

bud development and death of fine feeder roots may occur. In addition, high sodium levels may cause colloidal soil particles to disperse. This would lead to typical alkalinity conditions and problems.

The intent of the research was (a) to gather information on the accumulation of sodium and calcium in the soil along roads as a result of intensive salt applications throughout the winter, and (b) to demonstrate the effect of these agents on white pine growing along the roadsides. Results of this research will lead to a better understanding of the environmental influence of these de-icing agents on the roadside beautification of Michigan's Upper Peninsula.

LITERATURE REVIEW

The literature on use of salt as a highway de-icing agent indicates that these chemicals have only recently received attention. Early publications (Rudolfs, 1919; Strong, 1944) give evidence of a chemical effect on trees; but most of the scientific articles concerning chemical impact on vegetation, soil, or water were not published until recently. The public is aware of the serious nature of intensive, perennial use of these de-icing agents; and, as a result, more and more attention is given to their adverse effects on the roadside beautification strip (highway right-of-way).

During the period 1965-1969, Hutchinson and Olson (1967) and Hutchinson (1968) conducted intensive research on sodium and chloride levels in soils along highways in Maine. They sampled soils at 6- and 18-inch depths in pits located at 5-foot intervals up to 45 feet from the pavement. Analysis showed an increase in sodium levels at the 6-inch depth as far as 30 feet from the road. At the 18-inch depth, sodium level increases were found up to 10 feet away from the pavement. Their results indicated sodium levels were in the range of 30-40 ppm (μg/g) for the more distant soil samples. After one winter of road salt application, a maximum of 235 ppm sodium was found near the pavement edge. Other sites studied by Hutchinson showed increases in sodium at the 6-inch depths 4- to 8-fold higher adjacent to the pavement edge. He reasoned there is a carry-over and accumulation of salts within the soils from year to year.

One of these Maine study areas had previously received de-icing agents over an 18-year period. There was a maximum sodium build-up of 488 ppm in the 6-inch deep soil samples and 307 ppm in those at a depth of 18 inches in plots located 5 feet from the highway. Other study areas had sodium concentrations varying from 14 to 1,056 ppm.

Prior and Berthouex (1967) and Prior (1968) studied the accumulation of highway salts in soils along Connecticut highways. Soil samples were taken at the surface, 1-, 2-, and 3-foot depths. Sampling sites were located at 5, 25, 50, and 100 feet from the road. They showed these salts to be readily leached from the upper soil horizons into the "C" horizon.

Wester and Cohen (1968) described severe salt damage to vegetation following the very inclement winter of 1966-1967 in Washington, D.C. They studied the chloride levels of plant leaves taken from the roadside and the soils adjacent to highways. Concentrations of chlorides in the soils near untreated highways varied from 0 to 10 ppm while highways which were intensively salted contained levels as high as 900 ppm.

Other studies (French, 1959; Roberts & Zybura, 1967; Roberts, 1968; Verghese et al., 1969; Hanes et al., 1970) report facts which correlated plant injury with winter de-icing agents contaminating roadside soils and causing "chemical burn" to the vegetation. A four-year research completed in 1964 by Holmes and Baker (1966) concluded that salt does injure and kill sugar maple (*Acer saccharum* Marsh.). Injury to sugar maple foliage was obvious when sodium levels were in the 60-840 ppm range. Allison (1964) said that chloride accumulation in leaves near 10,000-20,000 ppm, due to uptake from moderate soil concentrations of 700-1500 ppm, would result in marginal burn, leaf drop, twig die-back, and eventual plant death. He also stated that sodium levels of 500 ppm result in noticeable plant injury. This damage is very evident in white pine and red pine (*Pinus resinosa* Ait.) where death is associated with chloride concentrations of 10,000 ppm while Scots pine (*P. sylvestris* L.) shows moderate injury and jack pine (*P. banksiana* Lamb.) and mugo pine (*P. mugo* Turra), little effect from road salts (Hofstra & Hall, 1971).

Research conducted by Thomas and Bean (1965) demonstrates the significance of sampling highway soil for salt contamination at specific times during the year. They suggested that these salts could kill plants and later be leached from the soil. It has been recommended that total soluble salts in soils be maintained below 100 ppm (Smith, 1944), but as early as 1964, soluble salts adjacent to salted parkways were found to be in the range of 1,860 to 2,580 ppm.

Recent studies revealed that 10% of the highway salt on any one day may become airborne (Milwaukee Journal, 1970). Research by Sauer (1967) and Hofstra and Hall (1971) suggests that salt spray from vehicular traffic is often the cause of plant injury along highways receiving de-icing agents.

DESCRIPTION OF STUDY AREA

The study area for this project is located in the SE¼, NE¼, Section 28, T48N, R26W, approximately 200 yards west of the Marquette County Airport entrance along the south side of U.S. 41. At this place the road is a divided, 4-lane highway extending generally east-west in direction. A white pine plantation established about 1930 extends to the highway right-of-way which is 7 meters from the edge of the pavement.

Soil series within the study area is in the Gogebic-Iron River-Vilas Association (Veatch, 1953, pp. 124-125), with the texture being sandy loam to sandy clay. These soils are low in lime and, generally, acid in nature. The reddish color characteristic of the soils in the Superior highland region persists. The underlying parent material is mainly sandy with red clay, beds of silt and fine sands and in places gravel, cobbles, and boulders in knolls, high knobs, and narrow ridges. Soils along the highway right-of-way were disturbed during road construction. For this reason there are no soil horizons within 7 meters of the road.

The geographic location of Michigan's Upper Peninsula and its proximity to Lake Superior subjects the area to long winters and great snow accumulations. In Marquette County snow is generally recorded from October to May. Winter snows are often intensive and in the winter of 1971-1972 few thaws occurred. By early March over 100 inches of cumulative snowfall had been recorded in the study area. Snow provided complete ground cover during the winter. The so-called 'snow field' often amounts to 30 to 40 inches in depth and, under such conditions, the well insulated soil never freezes.

PROCEDURE

I. SOIL ANALYSIS

Just prior to the winter of 1971-1972 highway salting program, concentrations of sodium and calcium levels at various depths were determined. Immediately following spring snow melt, sampling procedures were repeated and the salt levels compared with the fall data.

On October 31, 1971, 7 sampling sites were established. These were located 3, 5, 7, 9, 11, 13, and 34 meters from the south edge of the pavement. The 34-meter site served as a control since it was far from the highway and de-icing agents were not cast this distance.

A 1-meter soil analysis pit was dug at each site which assured sampling from all soil horizons in this area and made it possible to evaluate salt leaching. A 200 gram soil sample was taken from each site at 2 cm intervals down to a 20 cm depth and at 5 cm intervals thereafter down to 60 cm. A meter stick was secured to the wall of the pit and a garden trowel was used to obtain the soil samples which were sealed in clean plastic bags. The 126 samples were brought to the laboratory for analysis of sodium and calcium.

On May 15, 1972, immediately following the snow melt, soil samples were again taken and the same procedures as above were followed. Thus, any increase in sodium and calcium within the soil samples which resulted from accumulation of these salts in winter road de-icing applications could be determined.

In the laboratory, each soil sample was thoroughly mixed. A portion of each sample was placed on a 3-inch watchglass and put into a drying oven at 65°C for 24 hours. A Mettler balance was used to determine the weight of a 250 ml Erlenmeyer flask for each sample. The dried soil was then placed into the flask and again weighed and labeled. Approximately 100 ml distilled water was then added to each flask. The flasks were warmed to allow ready dissolving of any sodium and calcium present in the soil. While warming, the flasks were agitated to insure complete contact of the soil and distilled water. After mixing, the contents were suction-filtered twice, using Whatman No. 2 (11 cm diameter) filter paper. The filtrate was then filtered gravitationally with glass funnels. The volume of the resulting filtrates was determined by use of a 100 ml graduated cylinder. Approximately 35 ml of this solution was stored in autoclaved test tubes.

Flame photometry methods were used to determine the amount of sodium present in the filtrate and techniques of atomic absorption for the calcium content from each sample (Willard, Merritt & Dean, 1965, pp. 309-556). This procedure provides an accurate measure of the availability of these ions to pines growing in these soils.

II. WHITE PINE NEEDLE ANALYSIS

Throughout the 1971-1972 highway de-icing period needle samples were collected. The build-up of sodium and calcium on these needle samples was compared throughout the winter months.

Needles from 5 white pine trees growing along the roadside were gathered on the following dates: December 4, 1971, January 18, 1972, February 13, 1972, March 16, 1972, and April 20, 1972. These samples were taken from trees at a distance of 5 meters from the pavement edge and at the control site. Each sample of needles was sealed in a clean plastic bag and identified as to distance from the highway and elevation above the ground.

A portion of each needle sample was placed on a 3-inch watchglass and dried for 24 hours at 65°C. The dried needles were placed into weighed 250 ml Erlenmeyer flasks which were then reweighed and labeled. The procedure for soil analysis was also used for the needles.

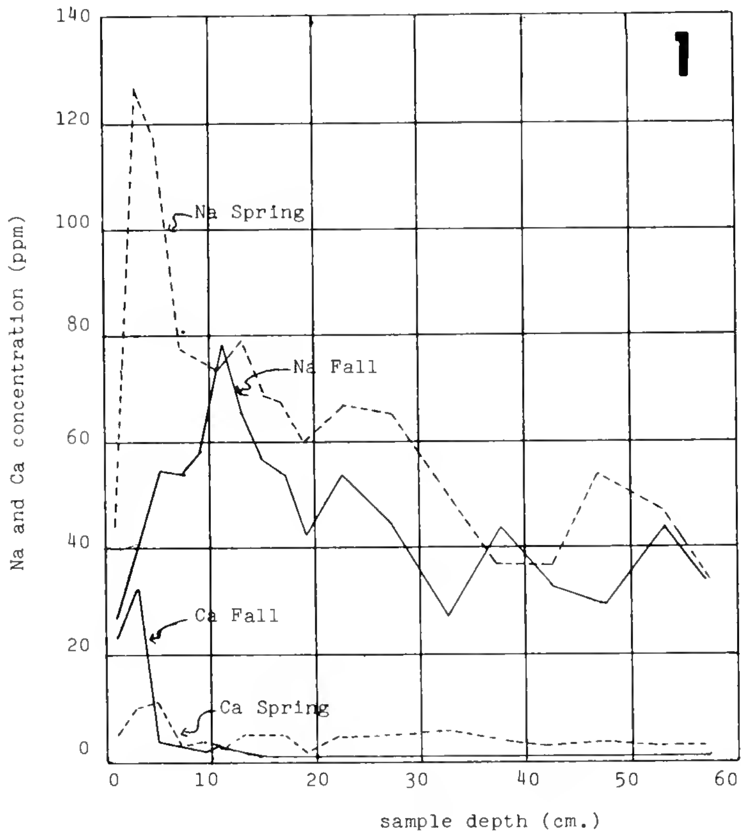
RESULTS AND DISCUSSION

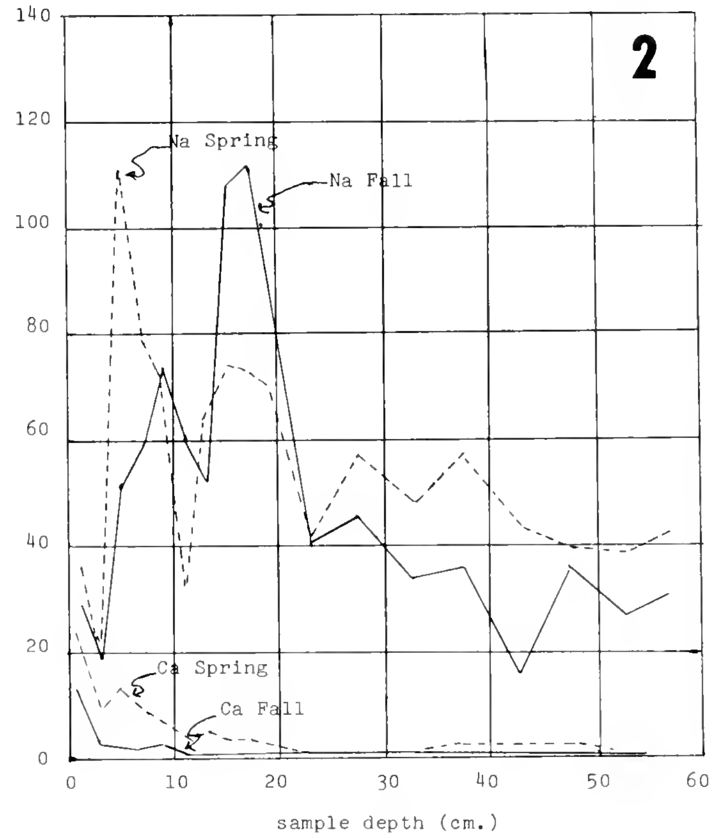
Forest pathologists recognize 2 major classes of tree diseases—organismal and those attributed to non-infectious agencies. Highway de-icing salts may cause serious injury to trees and are a non-infectious form of damage. There are several adverse influences which may develop. Foliage may suffer chemical burn, thus reducing its photosynthetic capacity to produce food. Salts may leach into the soil and impair normal microbial relations between beneficial soil fungi and mycorrhizae. Then, too, the chemicals—through intensive perennial use as a highway de-icing compound—may desiccate the trees by increasing the water suction potential of the soil and an abnormal sodium content would alter the normal photosynthesis and respiration rates. Since trees are so valuable to roadside beautification, research on their care and maintainance is significant.

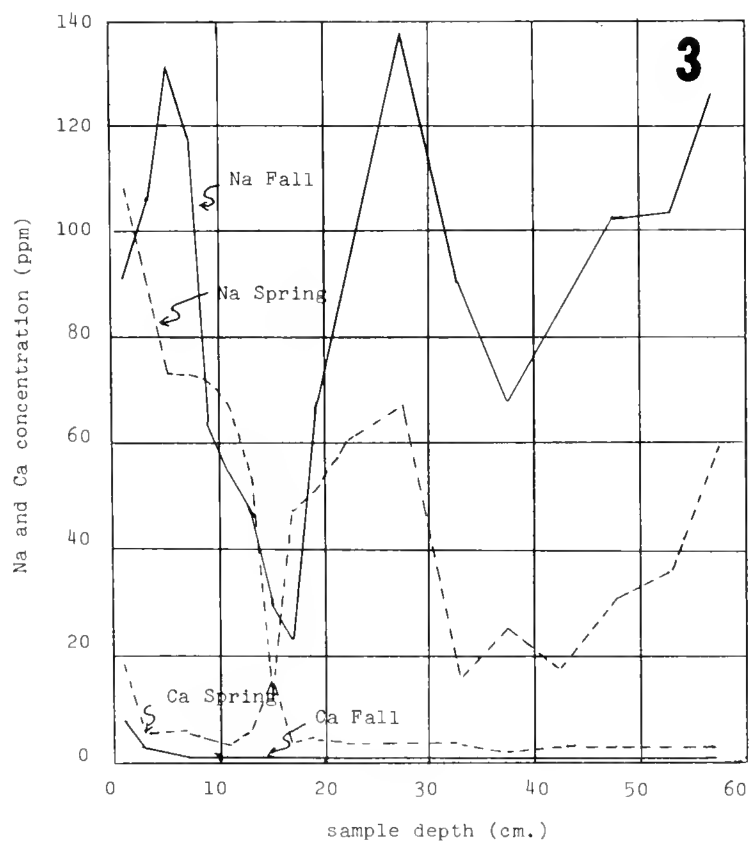
Since snow and ice are such important weather elements, it is natural to expect large quantities of highway de-icing chemicals to be used. Approximately one-third of the Ishpeming stockpile of de-icing agents was distributed over 11 miles of 4-lane highway (U.S. 41) between Ishpeming and Marquette. On the average, every mile of this part of the 4-lane highway received approximately 51 tons of sodium chloride and 193 yards of calcium chloride-sand mixture during the 1971-1972 winter months.

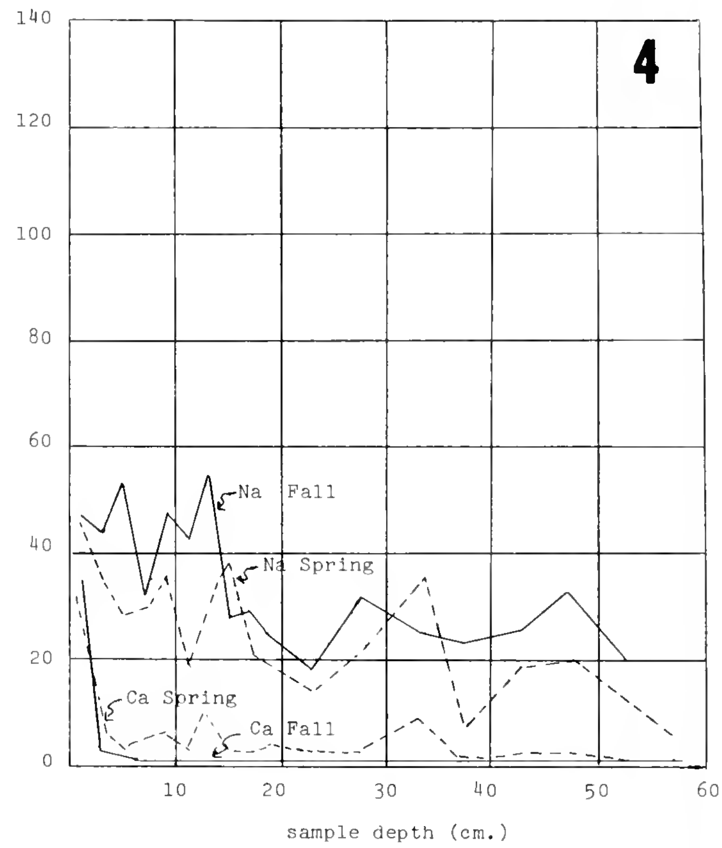
Snow melt did not occur until late April in 1972. Relative humidity reached 100% on several occasions. With such intensive use of de-icing chemicals, air turbulance from high-speed traffic, and strong prevailing winds, white pine trees along the highway were repeatedly exposed to salt spray.

Figures 1 through 7 represent soil concentrations for the sodium and calcium in the soils of the test pits. High concentrations of sodium in the soil could lead to an excess of these ions at the soil exchange sites. Under these circumstances the availability of some elements essential to vigorous plant



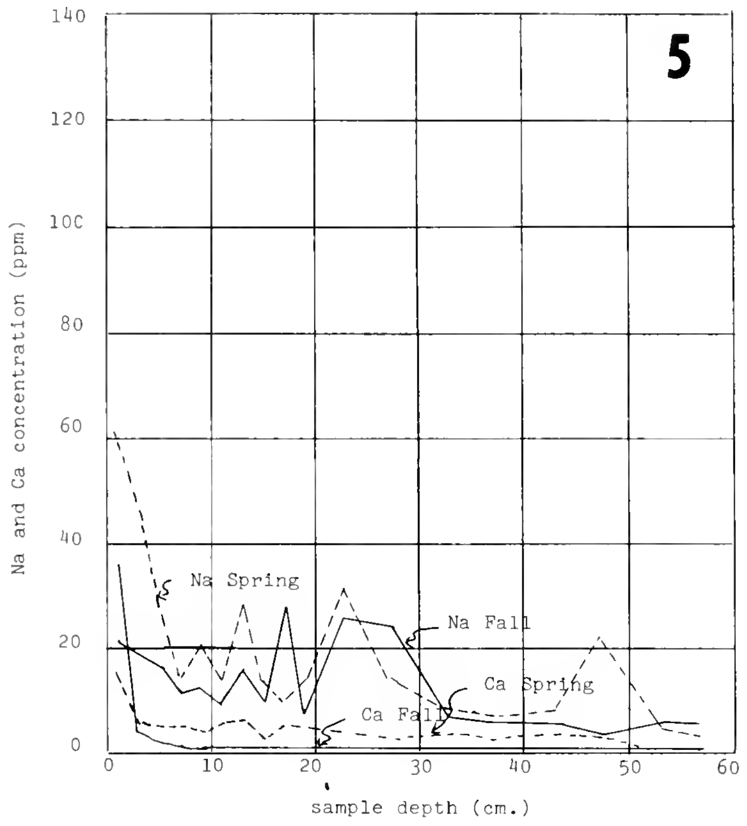


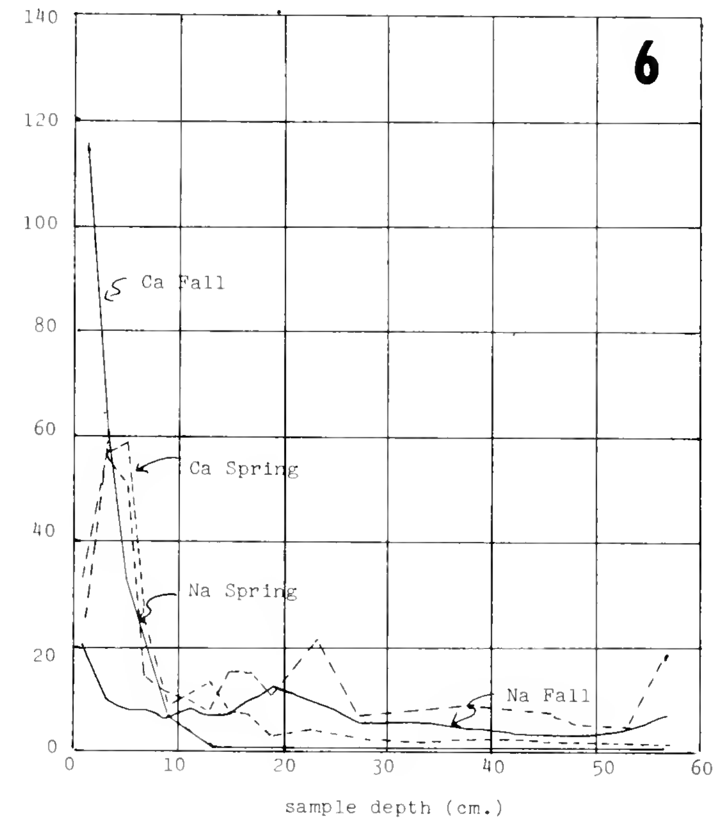


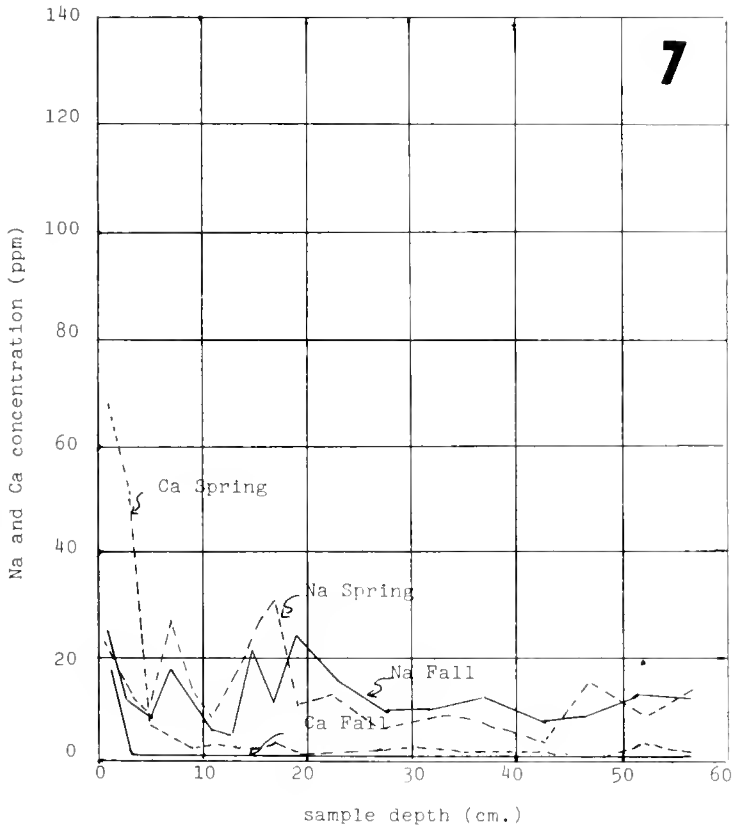


growth may be limited. In this study a distinct relationship was established between concentrations of sodium in the soil, soil sampling depth, distance from the highway, and time of year (fall or spring) at which the samples were taken.

Spring sodium levels within 5 meters of the pavement edge were much higher in surface soil samples than those collected in the fall. The highest spring concentration was 126 ppm at a depth of 2 to 4 cm and 3 meters from the highway. These levels dropped below 78 ppm for all samples taken below







Figs. 1-7. Spring and fall sodium and calcium concentrations at various depths within soil sampling sites:
Fig. 1. Site no. 1, 3 m from pavement.
Fig. 2. Site no. 2, 5 m from pavement.
Fig. 3. Site no. 3, 7 m from pavement.
Fig. 4. Site no. 4, 9 m from pavement.
Fig. 5. Site no. 5, 11 m from pavement.
Fig. 6. Site no. 6, 13 m from pavement.
Fig. 7. Site no. 7, 34 m from pavement.

the 4 to 6 cm depth at all sampling distances from the pavement edge. The highest spring sodium level found at a distance of 34 meters from the road was 31 ppm at a depth of 16 to 18 cm.

Beyond 7 meters from the highway, sodium build-up in the soil was not biologically significant. The highest sodium concentration recorded beyond this distance was 57 ppm. These data were obtained during the spring sampling period and were taken at a depth of 2 to 4 cm in the more distant soil pits.

Although there was a marked increase in sodium concentrations in the spring soil samples, sodium levels do not appear to be high enough to cause the chlorotic foliage conditions observed in white pine growing along the highway. It has been suggested that for healthy growth the salt levels should be below 100 ppm within the soil (Smith, 1944). Data from this study indicate that this standard is not now being seriously exceeded. It would appear that serious foliar burn is related to some factor other than high sodium concentration in the soil.

Calcium is an essential element for plant life. High concentrations of this element can lead to magnesium and manganese deficiencies and contribute to saline soil conditions. In this soil phase of the study a definite pattern of calcium accumulation was observed.

Fall soil samples contained calcium concentrations ranging from 115 ppm at 0 to 2 cm in the soil pit 13 meters from the pavement edge to 1 ppm from all sampling sites below 10 to 12 cm deep. There was a general increase in soil calcium levels immediately following the spring snow melt. Ranges were from 68 ppm at the control site and 0 to 2 cm deep to 1 to 4 ppm at the lower depths of all sampling sites.

There was a noticeable increase in calcium within soil samples taken near the surface and at 11-, 13-, and 34-meter distances from the highway. This increase could be (over a long period) the result of white pine needle cast and decomposition. As the needles decompose, some calcium (required for cementing cells of the middle lamella) would be re-cycled to the "A" soil horizon. The 3 sampling sites located nearest the pavement did not have a white pine canopy. Therefore, needle decomposition was not a factor contributing to calcium levels at these sites.

It is evident that calcium levels are much higher near the soil surface than at lower depths. The availability of calcium indicates that this essential element is not a limiting factor to white pine health and vigor. Again, the data show that the soil salt standards are not now being seriously exceeded.

The physiological effects of highway de-icing salts on foliage is not well understood. Annual die-back may be the result of constant winter salt spray due to high-speed traffic along highways on which de-icing agents are spread. This salt spray would act as a nonselective contact herbicide (Crafts & Robbins, 1962). A salt coating on white pine needles may alter their water diffusion gradient. Cells within the needles would then plasmolyze, giving up their water content to the salt coating. Also, these salts may be absorbed into the needles resulting in adverse physiological conditions. A distinct relationship was found between the time of the year and concentrations of sodium and calcium on needle samples (Tables I and II). Further correlations can be drawn between the elevation at which needle samples were taken above the ground and the distance these samples were taken from the highway.

There was an increase in sodium concentrations on white pine needles collected 5 meters from the highway as the salting program progressed throughout the winter months. Sodium levels were lower in the fall and higher in the spring for all white pine needle samples collected along the highway

TABLE I. Sodium levels (ppm) on white pine needles collected at various times throughout the 1971-72 highway de-icing months. Build-up of sodium concentration on the surface of needles is critical on white pine near the highway. A substantial progressive increase occurs as far as 34 meters from the pavement.

Sampling Date	Sampling Height above Ground (meters)	Sodium Level 5 Meters from Pavement (ppm)	Sodium Level 34 Meters from Pavement (ppm)
December 4, 1971	3	42	31
	4	37	29
	5	43	33
	6	28	21
January 18, 1972	3	102	47
	4	95	36
	5	79	57
	6	52	25
February 13, 1972	3	153	61
	4	129	52
	5	118	39
	6	73	33
March 16, 1972	3	268	70
	4	248	27
	5	237	43
	6	121	31
April 20, 1972	3	1,107	81
	4	994	110
	5	879	60
	6	129	52

and control site. Also, sodium concentrations on needles were higher on foliage 1 to 2 meters above the snow field. Conversely, for each sampling date, there was less sodium on needles located 6 meters up in the white pines examined. These sodium levels were noticeably higher at 5 meters distance from the highway than at the 34 meter distance.

Calcium concentrations on white pine needles sampled 5 meters from the highway increased as the winter months progressed. Samples taken from the lower part of the pines contained greater concentrations than needles from the upper regions of these trees. At a distance of 34 meters from the pavement, calcium concentrations followed this same pattern as on foliage of pines along the highway. However, there was not the marked increase in calcium on these needles.

Since infrared photography is useful in highlighting pathologic tissue this method was used to demonstrate the impact that highway de-icing agents have on white pine trees. The 700 to 900 mm sensitivity range of infrared film is an efficient range in which to work when studying plants and their disease conditions. This sensitivity range emphasizes chlorotic areas of foliage and

TABLE II. Calcium levels (ppm) on white pine needles collected at various times throughout the 1971-72 highway de-icing months. Calcium salt is used only sparingly as a de-icing agent on concrete and macadam roads. Nevertheless, these Marquette County measurements reveal a substantial build-up of calcium on pine needles near U.S. Highway 41.

Sampling Date	Sampling Height above Ground (meters)	Calcium Level 5 Meters from Pavement (ppm)	Calcium Level 34 Meters from Pavement (ppm)
December 4, 1971	3	3	12
	4	5	9
	5	4	6
	6	2	13
January 18, 1972	3	9	13
	4	11	15
	5	7	7
	6	8	10
February 13, 1972	3	28	17
	4	22	16
	5	19	12
	6	13	17
March 16, 1972	3	40	15
	4	68	25
	5	27	17
	6	30	22
April 20, 1972	3	33	19
	4	30	19
	5	49	10
	6	27	14

regions of stress which often are not observable by conventional film and filters or with the naked eye. As stress symptoms in the foliage become more severe there is a gradual loss in the ability of the needles to reflect infrared waves.

Because of the special properties of infrared film, healthy foliage records dark whereas necrotic areas and verdure under stress photograph in lighter shades. These color changes are the result of the behavior of radiation at the leaf epidermis and non-woody stems. In addition, color tones result from the variation in content of pigments such as chlorophyll, xanthophyll, and carotene.

It is significant that the only healthy-appearing white pine foliage found in the spring, close to the salted highway, are those covered by snow during the winter months (Figures 8 and 9). The upper branches of these same trees (above the snow field) were chlorotic in the spring and by May, 1972, appeared as foliage subjected to severe chemical burn. Structures of fungus fruiting bodies were not observed either above or below the snow field on any of the needles examined, thereby removing fungus as a cause of the change in needle appearance.

Fig. 8. Infrared photograph of young white pine in May after foliage was repeatedly exposed to highway de-icing salt spray. The only healthy, green needles are those covered during winter by snow drifts 3 to 4 feet deep.

Figures 8 through 10 show the necrotic conditions of the white pine needles within the salt spray zone caused by high-speed traffic. The specific symptoms were observed containing as high as 1,107 ppm sodium. Tip burn (browning) developed first. Browning became more severe until needle drop and twig die-back occurred (Figure 10). Some species like white spruce (*Picea glauca* (Moench) Voss) appear to have a high tolerance for de-icing agents (Figure 9).

Some of the literature suggests that uptake of sodium and/or calcium from the soil is responsible for chemical burn of foliage growing along highways (see citations in literature review). The evidence presented in this series of soil pit analysis and white pine needle salt contamination measurements do not support the contention that soil salt accumulation is the source of pathology. Conversely, infrared photographs of white pine trees, during the non-growing season, clearly indicated that chemical burn is responsible for needle necrosis. Pine boughs imbedded in the snow field were protected from salt spray throughout the winter. In May these branches were healthy and their needles were green. Above the snow field chlorotic conditions prevailed.

Fig. 9. Infrared photograph of white pine (left) and white spruce (right) after exposure to repeated, heavy salt spray applications. White pine under stress (light infrared image) is highly susceptible whereas spruce seems quite tolerant to the chemical spray.

If sodium and/or calcium uptake from the soil were responsible for this foliar injury all white pine needles would be affected alike, not just those above the protective snow field. It is clear from these Marquette data that chemical burn is due to salt spray contact on the needles.

SUMMARY

Soil samples were gathered during fall, 1971, and spring, 1972, to evaluate the accumulation of sodium and calcium in the soil along U.S. Highway 41, near Marquette, Michigan, as a result of intensive salt applications throughout the winter. Sodium levels were found to be higher along the highway immediately following snow melt than before the onset of the winter road de-icing program. Calcium levels did not increase sufficiently to induce severe plant damage by means of calcium uptake through the white pine roots.

White pine needles were systematically collected from trees growing 5 and 34 meters from the road. These samples were taken at various heights above the ground. The needles were analyzed for surface contamination of sodium and calcium. There was a noticeable accumulation of sodium on needles as the salting program progressed throughout the winter months. Sodium concentrations as high as 1,107 ppm were found on needles collected 5 meters from the pavement edge. Calcium concentrations on the white pine needles also increased as the winter months progressed. Concentrations of this

Fig. 10. Continued annual foliar die-back results in eventual die-off of limbs not protected by the snow field. Note the healthy, green vegetation beyond the salt spray zone.

ion were highest along the highway. However, calcium levels did not exceed 68 ppm on the needles sampled.

Specific symptoms of chlorotic white pine needles and limbs exposed to winter de-icing agents were observed. Needle tip burn developed first. Browning became more severe until needle drop and twig die-back occurred. These symptoms developed in the spring when snow melt began and the trees began to grow.

Infrared photography was used to demonstrate the impact of highway de-icing agents on white pine. The only healthy spring white pine foliage found along the roadside was covered by snow during the winter months. If foliar stress was due to uptake of sodium or calcium by the roots or a lack of available nutrients in the soil the snow covered limbs would also display unhealthy conditions. Therefore, needle necrosis in the result of salt spray contact on the white pine needles.

While this study is concerned only with the immediate contamination and accumulation of roadway de-icing agents and their effect on white pine there are other areas of environmental interest that need further study. Although the data presented show that salt damage causes distinctive annual die-back, other chemicals, such as cadmium and lead that are there because of the roadway, may also cause injury to roadside plants. Wind, alone, may contribute to tree damage through its desiccating effect. Industrial air pollutants like fluorides and hydrocarbons produce a widespread effect on vegetation. Certainly these influences must have some long-range effects on the overall growth pattern of evergreen trees in relation to annual shoot length, needle length, and perhaps even the "life time" of the needles.

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RESPROUTING CAPACITY OF OAK ROOTS: A TEN-YEAR EXPERIMENT

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An unexpected increase in tree density followed the settlement of the "oak openings" from New York to Wisconsin. Ground that had been sparsely timbered grew up within a few years to thick young forest, a fact documented not only by early observers like John Muir but also by comparison of present forests with surveyors' records. The usual explanation for the rapid increase in timberland, and that accepted by Curtis (1959), is that after Indians and pioneers ceased to set fires to insure green food for deer or for their cattle, oak "grubs" sent up sprouts which grew more rapidly than seedlings would have done and filled in the openings. The "grubs," as they have been named, are actually enlarged rootstocks of considerable age and size which persist after stems have been destroyed. The existence of such old rootstocks attached to seedling-sized trees has been documented many times; e.g. Beal (1889) noted that

> It is not difficult to find white oaks under eighteen inches high that are twenty or more years old . . . so it is not improbable, that in some cases seen, the parent root or grub was sixty to one hundred years old . . . .

John Muir (1965) wrote about

> ... the tap roots of oak and hickory bushes, called "grubs," some of which were more than a century old and four or five inches in diameter ... (p. 181)
>
> When an acorn or hickory nut had sent up its first season's sprout, a few inches long, it was burned off in the autumn grass fires; but the root ... sent up one or more shoots the next spring ... and so on, ... probably for more than a century, while the tops, which would naturally have become tall broad-headed trees, were only mere sprouts seldom more than two years old. Thus the ground was kept open like a prairie, with only five or six trees to the acre, which had escaped the fire... As soon as the oak openings ... were settled, and the farmers had prevented running grass-fires, the grubs grew up into trees and formed tall thickets ... so ... every trace of the sunny "openings" vanished. (pp. 183-184)

Such an explanation, reasonable as it is, is dependent upon two factors neither of which had been unequivocally demonstrated: First, that ground fires repeatedly swept the understory of savanna lands, during at least a century before settlement, at intervals of less than five years. Second, that oak seedlings are capable of enduring such repeated destruction. The first assumption can be tested only against imperfect historical evidence such as travelers' comments or the recollections of elderly men. The second assumption, however, can be tested. This paper records a test of the durability of oak seedlings and its results.

The test site was in the edge of an oldfield, last plowed about 15 years earlier, which is being colonized by oak seedlings. It was situated on sandy outwash in Sec. 6, T16N, R10E, in Marquette County, Wisconsin, on loamy sand of the Coloma series. The original vegetation was black oak savanna, a nearby remnant of which has been described in some detail (Whitford & Whitford, 1971). This site is about 15 miles north of the area described by Muir and of a similar nature, although perhaps a bit sandier and poorer in soil fertility.

In April, 1964, fifty seedling oaks, chiefly of the Hill's oak-black oak complex, but including a few white oaks, were cut within 7.5 cm of the soil surface, removing live tops as would a grass fire. The seedlings were from ½″ to about 1¼″ (approximately 1.2 to 3.1 cm) in diameter at their bases at the time of cutting and were clustered in the corner of an abandoned field near several acorn-bearing old trees. The area had not been disturbed since the last plowing 15 years earlier. There was no sign of old stems or scars at the base of any of the small trees cut for the experiment.

Each tree was cut, a metal stake and numbered tag placed next to the stump and the diameter of the stem 7.5 cm from the ground recorded. Each of the following years the sprouts were similarly cut and the number and diameter of sprouts recorded for each original seedling. Cutting was usually done in May, but in an attempt to reproduce natural fire patterns the cutting in two years was delayed until August, since early fall, like early spring, is usually a dry season when fires are probable. The ninth year the sprouts were not cut, but in the tenth (1973) they were cut twice, once in June and again in August. Despite the second cutting most of them showed vigorous new sprouts by September 15.

Fig. 1. Oak grubs with new sprouts, dug and photographed September 23, 1973.

By August, 1973, only 38 of the original stakes could be found. One or two had disappeared each year after the first, possibly trampled or removed by hunters. Of the 38 original individuals which were located, only 4 had ceased to put out shoots, i.e. about 90 percent survived. The average number of new shoots in May, 1965, was 4.27 per stub; in June, 1973, it was 2.87. Although the number of new sprouts per stump had diminished markedly, the 1973 sprouts were as large and vigorous as those of 1965. The average diameters of sprouts were 6.0 mm in 1965 and 6.8 mm in June of 1973.

Three of the roots were dug, measured, and photographed in September, 1973 (Fig. 1). They showed typical "grub" formation of a root crown much larger than the diameter of the originally cut seedling. One of them measured 11.4 by 17.8 cm at 7.5 cm below the surface of the ground, one 5.0 by 7.5 cm, and the other 6.3 by 7.5 cm. Ring counts indicated that they were 20 to 23 years old.

This study has shown that at least 90 percent of oak seedling roots survived after having all live top growth removed ten times in ten years. Since natural prairie fire would hardly have occurred so frequently the oak grubs would have endured them with no more than minor setbacks. Even annual fires set by Indians could apparently have been tolerated for as much as eight years and probably many more, particularly if there was an occasional lapse of a year or two in occurrence of the fires.

The pattern of diminishing seedling sprouts suggests that spring firing maintained with great regularity might eventually kill all or most of the underlying roots thus producing savanna or prairie.

The same pattern of diminishing sprouts, if it did not result in absolute destruction, would tend to obscure the evidence usually cited to recognize cutover or burned over forest, i.e. natural fires of intermittent occurrence would tend to produce many sprouts and therefore multiple trunked trees when they matured. Conversely, Indian fire maintained over a long period of years would tend to produce a forest of single or double trunked trees, almost indistinguishable by sight from a naturally seeded forest, when the fires were ended.

Having tested, even so briefly, the durability of oak rootstocks, I find it improbable that many sites would have been burned severely enough and frequently enough to entirely eliminate sprout regrowth, casting doubt on the old theory that fires converted oak forest to prairie.

SUMMARY

A ten-year study of resprouting, using annual clipping to simulate the effect of grass fires, proved that 10-15-year-old seedling trees showed approximately 90% survival after cutting of all new shoots each year. The average number of sprouts per root decreased from 4.27 the first season after cutting to 2.87 in the 10th growing season, but the average diameter of live stems remained about the same.

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Publications of Interest

NATURAL AREAS AND SCIENTIFIC AREAS. Scientific Areas Preservation Council, Department of Natural Resources, Box 450, Madison, Wisconsin 53701. 1975. A folder with excellent concise summary of activities in Wisconsin, with photos and a map indicating location and acreage of 124 tracts in the system. (See also Mich. Bot. 13: 190.)

SOME OF THE BEST FROM MICHIGAN NATURAL RESOURCES. Edited by John Gray. n.d. 80 pp. This colorful selection of articles from the magazine of the Michigan DNR is sent as a bonus with 3-year renewals, and includes articles on Michigan morels and protected wildflowers, as well as selecting a Christmas tree and other botanical subjects.

THE MICHIGAN NATURAL AREAS COUNCIL PROGRAM AND ITS EARLY HISTORY

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In many sections of Michigan today we find vast acreages of land being turned into industrial developments, shopping areas, highway routes, and real estate complexes. With modern equipment, thousands of acres of land with forests or other forms of natural vegetation—which required hundreds of years to develop—can be bulldozed clear in only a few days. With rapid expansion of cities and suburbs, often no plan is made to retain parks, open spaces, and educational tracts or to preserve woodlands and natural vegetation. On extensive real estate developments all trees and natural ground cover are destroyed and left barren so that many years will elapse before newly planted saplings can reach maturity. This is the situation that often exists today because of the lack of long-range planning.

As early as 1951, a group of far-sighted individuals, realizing the need for the protection and preservation of Michigan's outstanding natural features, formed the Michigan Natural Areas Council. It was the purpose of this citizens organization, composed of representatives of various conservation organizations and educational institutions as well as interested individual members, to seek out, investigate, and secure the dedication of typical natural landscapes of the state, which represent examples of various types of natural areas, unique natural features, and outstanding natural science values in Michigan. A wide variety of natural areas were included in this class of native lands, such as dunes, bogs, marshes, swamps, various types of woodlands, mountains, shoreline strips, natural meadows, prairies, streams, and ponds. Based on ecological principles, this program involved the preservation of plants, mammals, birds, insects, and other forms of wildlife and geological features. Included in this program were also historical and scenic features best preserved in a natural setting.

A series of interesting historical events led to the conception of a Natural Areas Council. Shortly after the State acquired the Edsel Ford estate near Highland known as Haven Hill, George Thomson and the writer visited this area, on May 11 and July 13, 1946. We found that the northern portion of this tract was a beautiful forested area in which were represented the common woodland types of southern Michigan. Recommendations were submitted to the Michigan Department of Conservation that this section of the Haven Hill estate be retained as a nature reservation and that an ecology trail be constructed jointly by the Department and the Southeastern Chapter of the Michigan Botanical Club.[1] Under the expert leadership of Charles Boehler, then research planner for the Conservation Department, the Wilderness Tracts and Trails Committee[2] of the Southeastern Chapter of the Botanical Club planned and constructed for the use of the public a unique Ecology Trail to demonstrate through signs along the route the principles of ecology and the special ecological features of the area. With the completion of this trail, it became evident that there was a distinct need for a policy that would emphasize the factors necessary for the maintenance of natural conditions: constant water levels, fire protection, restrictions on use of sprays, avoidance of cutting and filling, and protection from destructive disturbances. Stanley A. Cain,[3] one of the country's outstanding ecologists, then Botanist at Cranbrook Institute of Science, and Paul Van Buskirk, Planning Engineer for the Huron-Clinton Metropolitan Authority, together with the Cranbrook Herbarium Committee,[4] contributed generously to the formulation of a policy code drafted for the preservation and protective management of natural areas.

It was soon evident that there existed an urgent need for the preservation of natural areas throughout the entire state and that the policy code should be universally applied to all such areas. Therefore, the Wilderness Tracts and Trails Committee of the Southeastern Chapter suggested that the state organization of the Michigan Botanical Club create a Natural Areas Committee to promote such a program. Walter P. Nickell, then state president of the Club, appointed a Natural Areas Steering Committee[5] to carry out these aims. Education, conservation, and related organizations were requested to appoint representatives and these, with any interested individuals, formed a working group. Survey committees were selected to study and evaluate outstanding areas throughout the state, various categories were defined and classified, and the policy code for the protection of dedicated tracts was extended[6] and accepted. With a successful program under way—especially with widespread interest by many organizations and individuals—it seemed more fitting that this important program should be carried out by an independent organization. Consequently, under the guidance of the Michigan Botanical

[1]This work was initiated in the summer of 1946 by the Conservation Education Committee of the Southeastern Chapter: Paul W. Thompson (chairman), Mr. and Mrs. Edwin Boyes, Mr. and Mrs. Clarence Messner, Mr. and Mrs. Perry Reynolds, George W. Thomson, and Mr. and Mrs. Paul Van Buskirk. By 1948 the Committee had been augmented by Stanley A. Cain, Douglas Grubb, and C. Marvin Rogers.

[2] Members of the Committee were Stanley A. Cain, Douglas Grubb, Mr. and Mrs. Clarence Messner, C. Marvin Rogers, Mr. and Mrs. Carl Wilson, Mr. and Mrs. Paul Van Buskirk, and Paul W. Thompson (chairman).

[3]Dr. Cain later served the U.S. Department of the Interior as Assistant Secretary for Fish, Wildlife, and Parks.

[4]The Herbarium Committee was composed of Cecil Billington, Dale J. Hagenah; William Katz, Clarence Messner, Paul W. Thompson, George W. Thomson, and Stanley A. Cain (chairman).

[5]Margaret Haigh, Paul W. Thompson, and Genevieve Gillette (chairman) were members of this Steering Committee.

[6]The Policy Committee consisted of Stanley A. Cain, L. A. Danse, Clarence J. Messner, Alexander H. Smith, Paul Van Buskirk, and Paul W. Thompson (chairman).

Club, the Michigan Natural Areas Council was created on October 27, 1951, to continue this significant conservation program.

Early in the Natural Areas program, Percy J. Hoffmaster, then director of the Department of Conservation, stated (in January 1950) that a citizens organization such as the Council, composed of representatives of leading conservation and educational groups of the state, could make a very important contribution to Michigan. In the past, through the foresight of various people, areas possessing outstanding natural features and scenic values had been incorporated into State Parks and other state-owned units. The Conservation Department, he added, had neither the funds nor the trained personnel to make detailed studies and evaluations of these areas. On the other hand, the Natural Areas organization had members with ecological and scientific training fully qualified to carry out this work on a voluntary basis. He urged that such surveys be made, the findings incorporated in reports, and recommendations made to the Conservation Commission for the dedication of suitable areas. As a result of this far-reaching proposal, a program of this magnitude was to constitute the major part of the future activities of the Council.

Definitions of the types of natural areas, procedures for study and dedication of natural areas, and the selection of survey committees were incorporated into the constitution[7] of the newly formed Council. Once an area had been selected for consideration, a Reconnaissance Committee was appointed. This group made a thorough survey of the tract under consideration, noting its natural features, topography, geology, plant and animal communities, and any desirable scenic features. These findings were incorporated into a report with recommendations for the preservation of any desirable areas and submitted to the Council. If the Reconnaissance Report was accepted, a Site Committee was selected, which must include at least two representatives [later reduced to one] of the agency which administered the land. Usually some members of the Reconnaissance Committee served on the Site Committee. This committee reviewed the findings of the previous committee, considered any boundary adjustments needed, attempted to eliminate any conflicting uses that might occur, and then made a final report to the Council. Upon acceptance of the Site Report, the Council submitted recommendations for dedication of areas to the agency which administered these lands.

Natural areas tracts were classified by the Council into four different categories depending on proposed use: *Natural Area Preserve, Nature Study Area, Scenic Site,* and *Nature Reservation.* The Natural Area Preserve normally included one or more native habitats and was administered to give a maximum of protection and a minimum of disturbance to such areas. Usually the only facility provided was a simple foot trail that would lead to points of interest within the area so that the important features could be seen and studied, with

[7]The Constitution Committee was made up of Marion T. Hall, George W. Thomson, and Dale J. Hagenah (chairman).

most traffic confined to pathways to prevent destruction of the habitat. Research and educational studies were allowed if these did not damage the area.

The Nature Study Area was similar in administration but more use was contemplated. Marked and labeled trails were suggested and public facilities, including nature museums or interpretive services, were desirable if restricted to the edge or outskirts of the dedicated tract.

Scenic Sites protected scenic features, natural overlooks, and panoramic views, including waterfalls.

Nature Reservations were large areas reserved generally for the protection of natural features and might include one or more of the above tracts within their boundaries.

The first tracts dedicated, during April 1951, were four outstanding natural areas located at the Straits of Mackinac in Wilderness State Park.[8] These consisted of the Crane Island and the Sturgeon Bay Natural Area Preserves (the latter incorporating a stretch of scenic shoreline, low dunes, and inland forest and marshland), and the Waugoshance Point and the Big Stone Nature Study Areas. This last tract, consisting of conifer forest, mixed woodlands, bogs, and a variety of other habitats, constitutes a valuable wildlife refuge and an excellent outdoor educational facility.

Natural area dedications in three other regions of the state were to follow three years later. At Haven Hill in the Highland Recreation Area,[9] the western portion of the valuable forest in the northern sector was designated as a Natural Area Preserve and the eastern part was dedicated as a Nature Study Area. At Tahquamenon Falls,[9] the outstanding scenic Upper and Lower Falls areas were classified as Scenic Sites. The superb forests between the falls, along the north and south shores of the river, were designated as the Old Trail and the Southside Natural Area Preserves and the Between-Falls Nature Study Area (incorporating a river trail). Nearby, a large Betsy Lake Natural Area Preserve in the Lake Superior State Forest incorporated excellent examples of the northland wilderness, with muskegs, sand ridges, pines, cedar swamps, and shoreline vegetation at Clark, Sheepshead, and Betsy Lakes.

The third region was a Nature Reservation to protect the magnificent Porcupine Mountains[9] virgin forest wilderness. This outstanding tourist attraction consisted of unique waterfall, canyon, and mountain stream areas, and the famous escarpment ridge—the remains of one of the world's oldest mountain ranges.

[8]The Site Committee for Wilderness Park consisted of Charles Boehler, R. D. Burroughs, Walter P. Nickell, Alexander H. Smith, and Stanley A. Cain (chairman). Their recommendations were reviewed by Arthur Elmer, then Chief of the Parks Division of the Department of Conservation.

[9]Elzada U. Clover, William B. Drew, Ralph O'Reilly, George W. Thomson, and Paul W. Thompson (chairman) served on the Haven Hill Committee. The Tahquamenon Committee consisted of Stanley A. Cain, Alexander H. Smith, and Rogers McVaugh (chairman). Clarence J. Messner, Pierre Dansereau, and Shirley W. Allen (chairman) constituted the Porcupine Mountains Committee. Charles F. Boehler and R. D. Burroughs served on all three committees as representatives of the Department of Conservation.

In the years to follow, through Council efforts in cooperation with the Parks, Forestry, and Game Divisions of the Department of Conservation under Art Elmer, Ted Daw, George McIntire, and Harry Ruhl, a number of significant dedications were made on state-owned lands. As a result of these actions, a portion of Michigan's fascinating duneland country is preserved on South Manitou Island and at Warren Dunes State Park, including a series of ancient post-glacial dune ridges. Several outstanding virgin forests, both hardwood and conifer, have been retained, among which is the unusual pre-Columbian giant white-cedar woodland located in the South Manitou Island "Valley of the Giants." Bogs, swamps, woodland, ridges, lakes, and streams, with a variety of plants, animal life, and geological features, have been conserved.

A superb mountain wilderness tract was added to the list of dedicated areas when the Huron Mountain Club designated a large portion of their private holdings as a Nature Reservation, most of which was classed as a Nature Research Area—a new category adopted in 1960. This made available for special scientific study and research an outstanding area of northern forest and mountain lake country which is ideally suited to ecological studies. Although research is encouraged in all categories of natural areas, a Nature Research Area is dedicated primarily for scientific research, when because of its intrinsic nature or the wishes of the owner or managing agency it may not be satisfactorily classified in one of the other categories.

In addition to dedicated areas owned by various public agencies in Michigan, there are now 20 natural areas protected by agreements between the Council and private groups and individuals. The total area of lands dedicated on the recommendation of the Council exceeds 100,000 acres.[10]

The scope of the Council's work was broadened in 1966 by the adoption of a sixth category of dedicated areas—the Managed Tract. These lands are managed to preserve certain stages of plant succession, to demonstrate the effect of certain management techniques on vegetation and its associated wildlife, or for use in special research programs. Of interest in this category is the Kirtland's Warbler Management Area, which is managed to perpetuate the type of nesting habitat required by this endangered species. Designation of the Tobico Marsh as a Managed Tract reserves an important flyway station and meeting grounds for waterfowl. Creation of a prairie preserve by the Manistee National Forest near Newaygo retains by proper management a portion of the unique dry prairies of that section.

The Council's program on preservation of natural areas plays a significant and important role in Michigan's future, especially in relationship to long-range planning. So many conflicting land-use demands now exist and are increasing every year that there is a definite need to consider priorities in land-use projects. Scenic sites; unusual natural, historical, and geological features; and valuable plant and animal communities which require centuries

[10]See Ronald O. Kapp, Natural Area Preservation in the Age of the Megalopolis, Mich. Bot. 8: 30-35. 1969.

for development can only be retained through concerted efforts that demand their preservation and the assignment of a high priority to assure permanent protection of these unusual values.

As a consequence of the Council's program, in many of the larger State Parks the outstanding natural features have been protected, a number of valuable native landscapes have been conserved, and several important wilderness areas have been established. In a state where the tourist trade is one of the foremost industries, this is a significant consideration. However, to augment this accomplishment, the Council has specifically carried on a program to promote the location, recognition, and protection of scenic values such as waterfalls, panoramic views, and scenic overlooks.[11]

The Council has also stressed the important educational value of the outdoor museum and an interpretive program which will create an understanding and respect for the diverse groups of plant and animal communities which serve as outdoor laboratories. Meaningful conservation measures must be founded on the ecological principles portrayed by these natural features. A number of these ecological groups have been perserved but the great future demand for these facilities by educational institutions, community groups, scientific organizations, and by the general public requires that this program be greatly expanded. To be fully successful it will require the support and assistance of many persons.

Persons who would like to participate in the Council's program or any of its projects are invited to do so. Information can be obtained by addressing the Michgian Natural Areas Council, c/o University of Michigan Botanical Gardens, Ann Arbor, Michigan 48109.

ACKNOWLEDGMENTS

I wish to acknowledge the many helpful suggestions and comments contributed by George W. Thomson and Edward G. Voss.

[11]A Scenic Site Committee was composed of Ernest Blohm, Charles Boehler, Joseph Cox, and Arthur Wilcox (chairman). A preliminary inventory of scenic sites in the state was published in 1959.

TURION FORMATION IN WATER-MILFOIL, *MYRIOPHYLLUM FARWELLII*

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In cool temperate regions, according to Sculthorpe (1967), submerged and floating plants form "hibernacula which are essentially modified buds, the leaves rather than the axis being the major components." He also pointed to the considerable spectrum of form shown by these organs and suggested that the term "turion" be limited to the "more modified types, which have no exact terrestrial counterparts, and in which the leaves are specialised in form and quite unlike the normal foliage leaves (e.g. in *Hydrocharis*)." He considered the winter buds in *Myriophyllum verticillatum* L. to be turions. Löve (1961) used the winter buds of *M. exalbescens* Fern. as a characteristic to distinguish this species from *M. spicatum* L. Weber (1972) and Weber and Noodén (1974) published photographs of turions of *M. exalbescens* and *M. verticillatum* and gave ways of distinguishing between the turions of the two species.

Morong (1891) described *M. farwellii* from material collected by O. A. Farwell in a small pond in Keweenaw County, Michigan. Mr. Farwell had observed that although the plants were "frequently much longer than the depth of water in which they grow, the stems always curve over before reaching the surface and never protrude their tops in the air." The 'curving over' stems may have been the early stage of turion formation.

In August, 1974 and 1975, I observed the formation of turions in *Myriophyllum farwellii.* The 1974 plants were collected from Ramsay Lake, Gatineau Park, Quebec (MIN 656563); the 1975 collections were from a small unnamed lake near Itasca State Park, Minnesota (MIN 660310, MIN 660311). From both locations the distinctive turion-forming apex was apparent by August 22, (Fig. 1), and the turions had fully formed by October (Fig. 2).

On July 27, 1975, *M. farwellii* was observed in Minnesota to be flowering in the leaf axils and beginning to set fruit. In Quebec in early August 1974, plants were at virtually the same stage. Thus, the species completes its sexual cycle by mid-August, and begins forming terminal turions at a time when lake temperatures in the littoral zone are above 20°C. Lateral turions are also formed occasionally, but these are smaller, and form later in the season.

Turion leaves are considerably shorter than the normal leaves and relatively stiffer in texture. The leaves that are produced when the turions first germinate are also shorter and stiffer than typical adult leaves. In the humic lakes where *M. farwellii* was collected the plants and the turions are brown, but when transplanted to much clearer water in a greenhouse pool they turn deep green. The terminal turions are commonly curved in a way

Fig. 1. *Myriophyllum farwellii.* Terminal apices from the same plant collected August 22, 1975, in central Minnesota. Left, vegetative apex. Right, turion-forming apex.

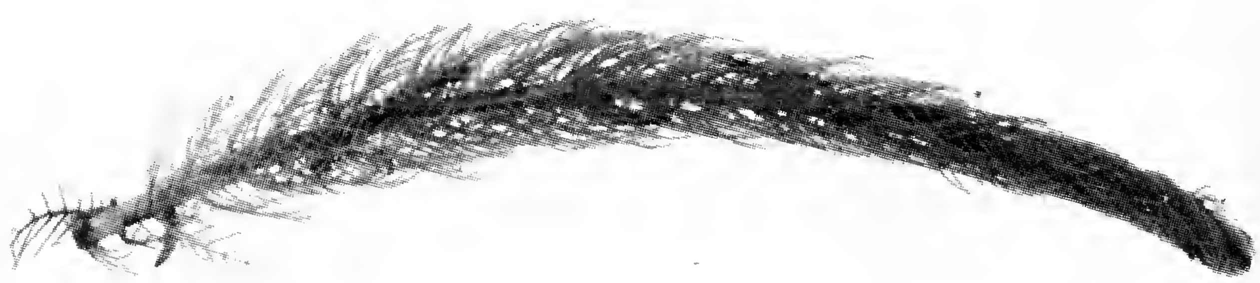

Fig. 2. *Myriophyllum farwellii.* Turion formed by a plant collected in Quebec, August 1974. By December, the parent plant of the previous season had decayed, leaving the turion.

which resembles the U-shaped germinating turions described by Weber (1972) for *M. exalbescens.* Turion tissue is heavier than water and much more compact than typical stem tissue which floats if detached from the plants. The change in tissue density at the turion-forming apex may contribute to the curving over of the stems and certainly facilitates sinking of the turions as the parent plant decays. During the winter, turions are released from the decayed adult plant and serve as a means of vegetative propagation.

The other *Myriophyllum* species in which turions have been described (*M. exalbescens* and *M. verticillatum*) flower on terminal aerial spikes and usually produce lateral turions, although terminal turions are produced by shoot tips that have not flowered. In these two species, flowering often continues until September, and turion formation which seems to follow flowering occurs so late in the season that Weber and Noodén (1974) concluded that temperature was a factor influencing turion induction in *M. verticillatum* when it occurred in mid-October. They felt that day length could also be important. Because it was so late in the season they were unable to separate the effects of the two factors. The relatively high temperatures at which turion formation occurs in *M. farwellii* is an interesting contrast and may implicate day length. At the Minnesota latitude the day length changes from approximately 16 hours in mid-summar to 14 hours by August 20. Weber (1973) found that day lengths of less than 12 hours were required for turion induction in *M. verticillatum.*

More than 50 years ago. Glück (1906) and Arber (1920) germinated *M. verticillatum* turions in a "vessel of water, over-crowded with other aquatics" and in a "glass vessel with water but without earth." The turions grew into "richly rooted plants" more than 30 cm long but by April 1, these plants had all formed new turions. Both workers concluded the turions had formed in response to unfavorable conditions. Goebel (1903) and Glück (1906) considered that "competition for food" was a major determinant in this experiment but not necessarily so in nature. Arber (1920) felt that under natural conditions it was most likely "the lowering of the temperature in the autumn which induces the formation of winter-buds." All indications are that these workers experimented with turions in day lengths of less than 12 hours and that this, rather than nutrient limitations or temperature, could have been the controlling factor.

Turions of *M. farwellii* give support to this interpretation. Some that were placed in soil and kept at 15-20°C in a greenhouse pool over winter remained dormant until the following spring when they grew very slowly. There was no change in temperature or nutrient supply when they began to grow, but day length had increased to 13-14 hours. The slow growth of the turions suggested that a winter vernalisation may have been desirable to aid the breaking of dormancy. Turions of *M. farwellii* given a 1-month cold treatment in the fall of 1975 and then placed in the greenhouse pool in mid-November, began to develop roots and to elongate slightly, apparently in response to warmer temperatures. There was little evidence of new leaves forming, which suggests the turions do not truly break dormancy until the day length is 13-14 hours.

In conclusion, it seems likely that day length may be a major factor in the induction of turion formation in *M. farwellii* and that it also mediates the duration of the subsequent dormant period.

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Publications of Interest

THE FLOWERING PHENOLOGY OF NORTH AMERICAN PLANTS A BIBLIOGRAPHY. By Keith E. Roe and Eunice M. Roe. Life Sciences Library, Pennsylvania State Univ., University Park, Pennsylvania 16802. 1975. 26 pp. + 2 pp. Addenda. $1.00. After a very brief introduction on the history, methods, and uses of floral phenology studies, with its own bibliography, this useful publication lists 250 titles on the subject. A map helps to key these to regions of the continent, but there is no other index.

ORGANISMS AND BIOLOGICAL COMMUNITIES AS INDICATORS OF ENVIRONMENTAL QUALITY–A SYMPOSIUM. Ed. by Charles C. King and Lynn Edward Elfner. Ohio Biol. Surv. Informative Circ. 8. 1975. 65 pp. $2.00 (OSU Press, 2070 Neil Ave., Columbus, Ohio 43210). Derived from a symposium held at The Ohio State University in March of 1974, this report includes brief contributions on various sorts of organisms as indicators of environmental quality (e.g., lichens, white pine, arthropods, aquatic vascular plants, fungi); a general paper on "Natural Areas as Environmental Monitors" is unfortunately represented by only a bare outline. As the preface begins, "Life is the ultimate environmental monitor." These contributions with their often useful references bring together much diverse information on the subject.

TAXONOMIC STATUS OF THE *ONOSMODIUM MOLLE* COMPLEX (BORAGINACEAE) IN WISCONSIN

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The genus *Onosmodium,* the false gromwells or marbleseeds, is represented in Wisconsin by two entities which in the familiar narrow concepts are called *O. hispidissimum* Mack. and *O. occidentale* Mack. (Figs. 1-2). These and the three other taxa mentioned below have been recognized as distinct entities ever since each was originally described, with plant taxonomists applying to them either specific status (Deam, 1940; Fernald, 1950; Gleason, 1952; Steyermark, 1963) or varietal status (Cronquist, 1959; Gleason & Cronquist, 1963; Morley, 1969). A study of specimens in the herbaria of the University of Wisconsin, University of Wisconsin-Milwaukee, Milwaukee Public Museum, and the Univeristy of Michigan has contributed to the understanding of this complex by detailing the morphological variation in Wisconsin and has shown that *O. hispidissimum* and *O. occidentale* are partially merging, major races which seem best treated as subspecies belonging to the *O. molle* complex. According to evidence from cursory observations on non-Wisconsin taxa and

Figs. 1-2. *Onosmodium molle* ssp. *occidentale.* Photographed at the University of Wisconsin Arboretum, Madison, Wisconsin, July 13, 1974. Fig. 1. (left). Habit view. Fig. 2. (right). Terminal portion of inflorescence of the same plant. In *Onosmodium* the corolla opens, the style exserts, and the anthers mature long before the corolla develops completely.

from morphological and geographical information presented in floras, the situation of *O. hispidissimum* and *O. occidentale* is paralleled by that in *O. molle, O. bejariense,* and *O. subsetosum,* which likewise show overlaps and transitions in sympatric areas. For practical as well as evolutionary reasons the same rank in a formal sense should be inferred for them.

NOMENCLATURE

The following new combinations assign subspecific rank to the major geographical variants of *Onosmodium molle*:

Onosmodium molle Michaux subsp. **hispidissimum** (Mack.) Cochrane, *stat. nov.*
Onosmodium hispidissimum Mack., Bull. Torrey Bot. Club 32: 500. 1905.
Onosmodium molle var. *hispidissimum* (Mack.) Cronq. in Hitchcock et al., Vasc. Pls. Pac. N.W. 4: 234. 1959.

Onosmodium molle Michaux subsp. **occidentale** (Mack.) Cochrane, *stat. nov.*
Onosmodium occidentale Mack., Bull. Torrey Bot. Club 32: 502. 1905.
Onosmodium molle var. *occidentale* (Mack.) Johnston, Contr. Gray Herb. 70: 18. 1924.

Onosmodium molle Michaux subsp. **bejariense** (DC.) Cochrane, *stat. nov.*
Onosmodium bejariense A. DC., Prodr. 10: 70. 1846.
Onosmodium molle var. *bejariense* (A. DC.) Cronq. in Hitchcock et al., Vasc. Pls. Pac. N.W. 4: 234. 1959.

Onosmodium molle Michaux subsp. **subsetosum** (Mack. & Bush) Cochrane, *stat. nov.*
Onosmodium subsetosum Mack. & Bush ex Small, Fl. S.E. U.S. 1001. 1903.
Onosmodium molle var. *subsetosum* (Mack. & Bush) Cronq. in Hitchcock et al., Vasc. Pls. Pac. N.W. 4: 234. 1959.

DISTRIBUTION AND HABITAT

Both sspp. *hispidissimum* and *occidentale* are widespread in the eastern one-half of North America. The former, primarily eastern in distribution, reaches the western edge of the deciduous forest west of the Mississippi River. In *Gray's Manual* (Fernald, 1950, p. 1201) its range is described as "N.Y. and s. Ont. to Minn. and Neb., s. to N.C., Tenn., La., and Tex." According to Fernald (p. 1200), *O. occidentale,* a taxon of the Great Plains grasslands, ranges from "Minn. to Sask., s. to w. Ill., Mo., Okla., Tex. and N.M." The occurrence of the latter east of the Mississippi River is limited to western Illinois and Wisconsin.

Wisconsin is included in the broad zone where the ranges of these two races overlap. An earlier report on the Boraginaceae of Wisconsin (Cochrane, 1975) cited previously unreported specimens and published geographical records of *Onosmodium molle* in Wisconsin.[1] Besides providing improved

[1] I would like to call attention to an error in my 1975 paper, p. 122, where a collection of *Onosmodium molle* from Rock County (*H. Skavlem* in 1889, WIS) was referred to var. *occidentale.* While recognizing that the specimen is poor, in this case being a single immature branch, I am now confident in redetermining it as ssp. *hispidissimum* and thus also in restoring it as the voucher supporting the published record in Musselman et al. (Mich. Bot. 10: 183. 1971).

distributional data, recent field work has supplied information on frequency and habitat for both subspecies and has brought out the need for more critical study of this small but complex group.

In Wisconsin *Onosmodium molle* is local, its distribution corresponding to the region underlain by limestones, including the Ordovician Galena and Prairie du Chien and the Silurian Niagara dolomites. Populations of ssp. *hispidissimum* meet ssp. *occidentale* in the deciduous forest-prairie border region and are largely replaced by it in the southwestern quarter of the state (Cochrane 1975, p. 121).[2] While their ecological behavior does not seem to be very different, it is not known whether or not the two subspecies ever grow together. Both occupy dry open habitats, such as prairies and weedy openings on rocky wooded slopes. Subspecies *hispidissimum,* which has been collected in sandy ground, often grows along shores and on streambanks; ssp. *occidentale* occurs typically on very dry thin-soiled prairie remnants on flat dolomite ridges and steep south- and southwest-facing blufftops and hillsides, on some sites scattered, on others common to abundant. It is regularly associated with a large number of typical prairie species, including *Andropogon scoparius, Bouteloua curtipendula, Petalostemum purpureum, Amorpha canescens, Rhus glabra, Lithospermum incisum, Coreopsis palmata, Kuhnia eupatorioides, Aster sericeus,* and *A. ericoides,* or less often with *Potentilla arguta, Psoralea esculenta, Petalostemum candidum, Scutellaria parvula* var. *leonardii,* and *Helianthus occidentalis.* It was collected once as an adventive elsewhere, namely on a sandy roadside near Kieler in Grant County (*D. DeMaster* in 1972, WIS). Apparently the occurrence of ssp. *occidentale* in the ecologically "open" xeric prairie, a community limited to a rigorous habitat in which few species can compete, may be responsible for its local distribution in Wisconsin. Many other more or less widespread species of dry plains and prairies which are otherwise restricted in the state occur in this same environment. Some of these, including *Psoralea esculenta* and *Astragalus caryocarpus,* have very localized distributions similar to that of ssp. *occidentale* and like the latter reach their eastern limits here.

GROSS MORPHOLOGY

My study supports Cronquist's reduction (1959) of *Onosmodium hispidissimum* Mack., the Texan *O. bejariense* A. DC., and the Ozarkian *O. subsetosum* Mack. & Bush to infraspecific status under *O. molle.* However, examination of specimens leads to the conclusion that the separation of Wisconsin entities is not as easy as indicated in his keys (cf. also in Gleason & Cronquist 1963, p. 575).

Nutlets.—Subspecies *hispidissimum* is characterized as having collared fruits 2.5-3.5 mm long and *occidentale* as having collarless fruits 3.5-5 mm long.

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[2]One specimen (*J. Schuette 38812* in 1890, WIS) was mapped with trepidation. For locality data its label gives "Shore of Green Bay, Wisconsin," and, although the great majority of Schuette's extensive collections were made in Brown County in the vicinity of Green Bay, this plant actually may have come from Door County.

Although these differences are fundamental, they often fail to correlate. A limited analysis of thirty-four sheets of Wisconsin *Onosmodium* is summarized in Fig. 3. If only the most conspicuous character is used, the qualitative presence or absence of an evident basal collar, eight of the eighteen sheets bearing fruit are clearly identifiable as ssp. *hispidissimum.* If instead the size categories stated above are employed, only five specimens, those with nutlets mostly 3.5 mm or less long, would fall into that same subspecies, and all of these have fruits which are without collars. There is no demonstrable line between fruits 3.1-4.2 mm × 2.5-3.2 (-3.4) mm (*occidentale*) and fruits 3.3-4.3 × 2.4-3.1 mm (*hispidissimum*); in fact, if there is any tendency at all, it is for a collar to be associated with larger rather than smaller fruits.

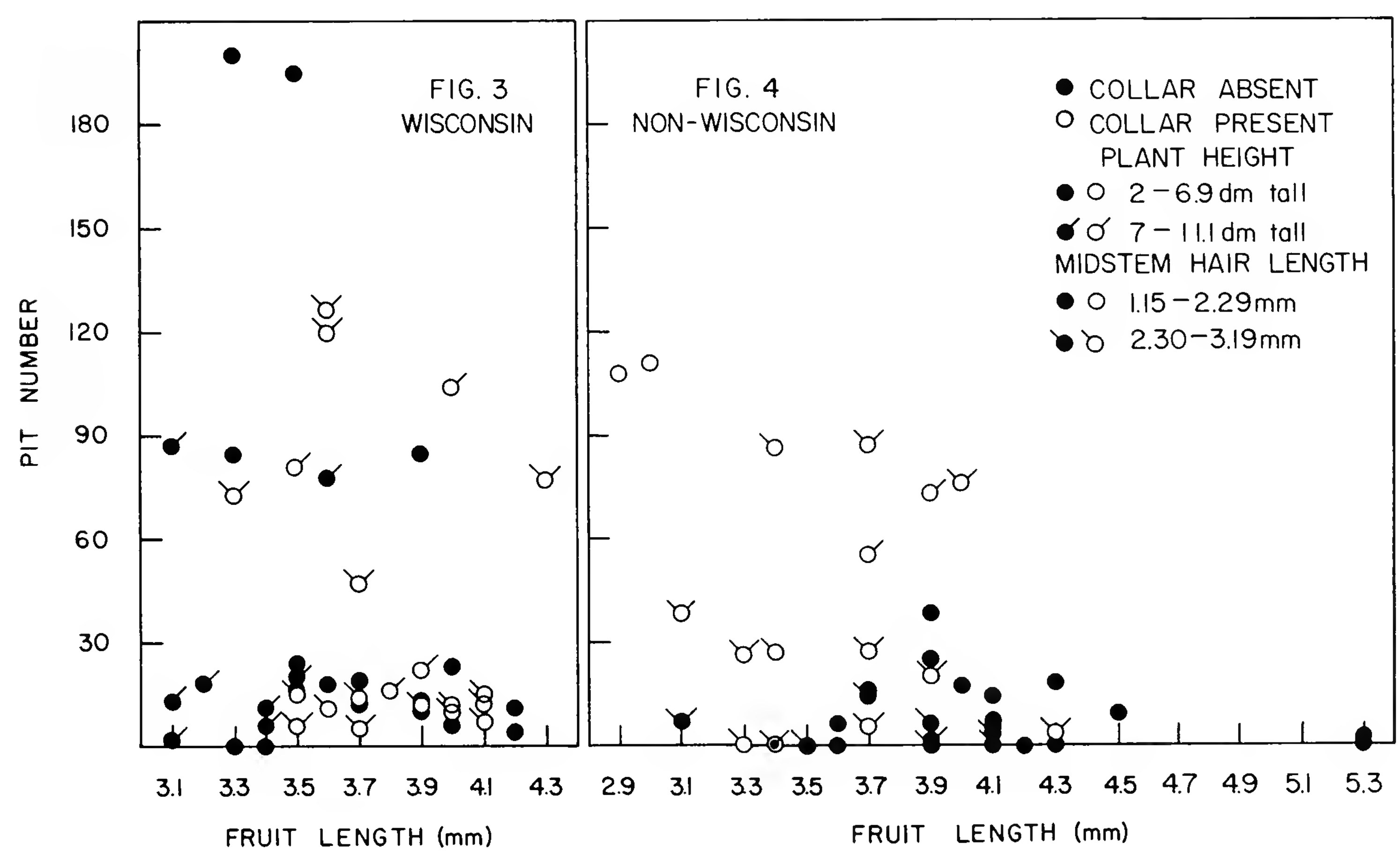
Cronquist attempts to use nutlet luster and texture as taxonomic characters, describing those of ssp. *hispidissimum* as "mostly dull and smooth or nearly so" and those of *occidentale* as "smooth and shining." On this basis it is not possible to demonstrate discontinuities. There is no detectable difference in degree of shininess, and the minute pits, which, shallow or deep, may range in number from 0 to 200 sometimes give the nutlets roughened surfaces which can hardly be described as "smooth." Steyermark also emphasizes the pit character, stating in his key (1963, p. 1244) that in *O. occidentale* the fruits are usually without pits, while in *O. hispidissimum* they are usually pitted. However, a scatter diagram (Fig. 3) does not reveal any particular correlation between number of pits and other characters, confirming that pitting is of no more taxonomic value in distinguishing these two subspecies, in Wisconsin at least, than is pericarp color. (The latter varies continuously from bone white to cream to brown-tinged.)

When collections of these two subspecies from outside of Wisconsin were graphed (Fig. 4), the result was not a checkerboard pattern of variation as it was for Wisconsin plants but one that showed greater correlations between the characters plotted. Along with lower variability in pit number and greater variability in fruit length, definite trends toward higher pit numbers for collared fruits and greater size for collarless fruits emerged. However, the latter relationship remained quite variable and hence taxonomically unreliable. Obviously the amount of variation detracting from any positive correlations was reduced and consequently the definition of the taxa enhanced by the elimination of data from the Wisconsin specimens. A similar assessment of the situation would have applied if data from certain Illinois plants had been excluded also. The scatter diagrams presented here should not be regarded as summarizing the total variability of the taxa because the number of specimens at my disposal was small. Nevertheless, while more data are desirable, it is evident that only the collar character is consistently dependable when identifying fruiting individuals to subspecies.

Habit and indumentum.—Differences in habit, such as plant and leaf size, and indumentum, such as hair length, density, texture, color, and angle of divergence, are sufficient to permit the separation of recognizable geographical races. Of these characters plant height and the lengths of longer midstem hairs were deemed the two most convenient for use in Figs. 3 and 4. Plants of ssp.

hispidissimum are a little more robust than those of ssp. *occidentale,* ssp. *molle,* or the weakly distinguishable ssp. *bejariense.* Six of the 11 Wisconsin sheets of ssp. *hispidissimum* examined have intact stems, and of the latter all are 7 dm or more tall. Of the 12 Wisconsin sheets of ssp. *occidentale* with intact stems nine (75%) also are 7 dm or more tall. Among the 47 non-Wisconsin specimens of ssp. *occidentale* studied 21 have intact stems; of these only 6 (29%) reach or exceed 7 dm in height. This trend for reduced plant height westward along with that for increased pubescence density discussed in the following paragraphs may be expected, since populations or series of populations of many other prairie species, for example, *Aster ericoides* and *Solidago missouriensis,* show the same kind of character gradients over their areas of distribution.

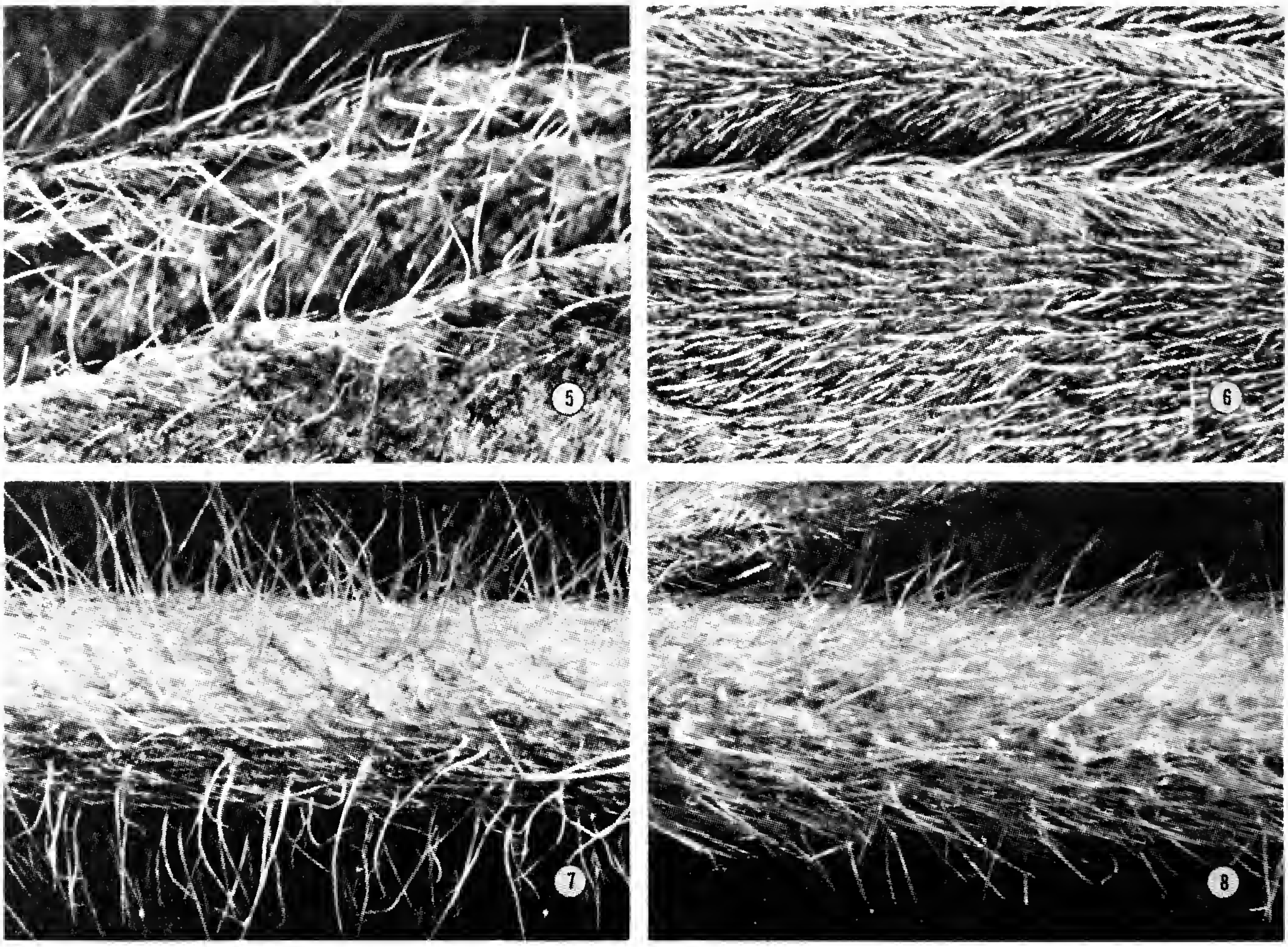
Typical stem and leaf surfaces of sspp. *hispidissimum* and *occidentale,* which along with ssp. *bejariense* have been described by Johnston (1964), are shown in Figs. 5-8. Although hair length is quite diagnostic, there is some overlap, especially in non-Wisconsin specimens, as well as some variation in other trichome characters. Plants from Wisconsin having the longer midstem hairs (0.1-) 1.3-2.2 mm long can be assigned to *occidentale* and those with the longer midstem hairs 1.6-3.4 mm long to *hispidissimum.* All specimens of the latter bear at least some hairs 2.3 mm or more long with one exception. That plant (*H. Iltis & J. Thomson* in 1964, WIS) has the collared, pitted fruits of



Figs. 3-4. Pictorialized scatter diagrams comparing fruit lengths and the number of pits per fruit and indicating plant height and midstem hair length of two subspecies of *Onosmodium molle.* Fig. 3. Wisconsin collections. Fig. 4. Non-Wisconsin collections. Hollow dots are ssp. *hispidissimum* and solid dots ssp. *occidentale.* Specimens measured are deposited in the herbaria of the University of Wisconsin-Madison (WIS), University of Wisconsin-Milwaukee (UWM), Milwaukee Public Museum (MIL), and University of Michigan (MICH).

ssp. *hispidissimum,* but the midstem hairs are as short (1.1-1.8 mm) as in ssp. *occidentale.* Furthermore, its leaf pubescence agrees with the description given under *occidentale* in the key below. I have treated three other specimens (*T. & R. Hartley 1047*, WIS; *M. Nee 5340,* WIS; *M. Nee 5407*, WIS) as ssp. *occidentale.* Although they have the hairs between the veins on the lower surfaces relatively sparse and appressed and some of those on the veins scythe-shaped and hispidulous, the pubescence is generally short and soft, and the fruits, when present, are collarless. The pattern of hairs on the leaves of one specimen of ssp. *occidentale* (*J. Thomson* in 1972, WIS) is very unusual, the relatively sparse hairs being not only extremely short and stiff but also nearly all appressed. Another specimen (*H. Smith 7216*, MIL, WIS), while agreeing with ssp. *occidentale* in hair texture and length, has ocher-yellow hairs like those exhibited by specimens of ssp. *hispidissimum.*

Elsewhere in the *Onosmodium molle* complex as well certain individuals and occasional populations do not always conform clearly to the distinctions



Figs. 5-6. Photographs of lower surfaces of cauline leaves of representative specimens. Fig. 5. *Onosmodium molle* ssp. *hispidissimum* (*E. Fell 58-498,* WIS). Fig. 6. *O. molle* ssp. *occidentale* (*D. DeMaster* in 1972, WIS).

Figs. 7-8. Photographs of portions of stems of representative specimens. Fig. 7. *Onosmodium molle* ssp. *hispidissimum* (*E. Fell 58-498,* WIS). Fig. 8. *O. molle* ssp. *occidentale* (*H. Greene & J. Zimmerman* in 1948, WIS). All figures photographed at the same magnification.

established by Cronquist and other authors in their floras. The nutlets of one of our two specimens of ssp. *molle* (*A. Sharp et al. 9798*, WIS) are somewhat pitted but large-sized (3-3.4 mm), and they are the shiniest seen. Typical ssp. *molle* is supposed to have small (2.5-3 mm), dull nutlets. Correll and Johnston (1970, p. 1310) noted that Texas plants representing *O. occidentale* from north of Tarrant Co.: "... are usually coarse and hispid." A specimen from that region (Grayson Co.: *V. Cory 59121*, WIS) combines collarless fruits with unusually long pubescence (midstem hairs 3.1-4.1 mm, the longest among all material examined save for those of ssp. *bejariense*). It is probable that ssp. *occidentale* intergrades almost as freely with sspp. *subsetosum* and *bejariense* toward the south as it does with ssp. *hispidissimum* toward the north.

A NOTE ON THE INTERPRETATION OF INTERMEDIATE POPULATIONS

Similar patterns of high variability or morphological intermediacy for otherwise more or less uniform but related taxa are known in other East-West species and subspecies pairs whose ranges overlap in the upper Midwest. Such is the case in *Cyperus* (Marcks, 1974), *Gentiana* (as *Gentianopsis*, Iltis, 1965), *Hudsonia* (Skog & Nickerson, 1972), *Lycopus* (Henderson, 1962), and other genera in which hybridization with backcrossing apparently explains the occurrence of complex intergrading populations in recently deglaciated territory. Whether the genecological variation patterns displayed by the *Zigadenus elegans* (Hultén, 1973) and *Onosmodium molle* complexes are the result of complicated clinal patterns or the consequence of introgression is a matter awaiting further detailed paragenetic studies. It seems reasonable to believe that the complexes of characters centering around the defined subspecies in *Onosmodium molle* and also in other groups have differentiated as the result of the former process rather than to assume that introgressive hybridization is necessarily involved.

SUMMARY

Onosmodium molle is a very widespread species showing considerable variation in habit, pubescence, and fruit characters. Over its range a series of five more or less distinctive populations, here treated as subspecies, can be distinguished, although some specimens show overlapping or recombining characters so as to appear variously intermediate between the subspecies.

Wisconsin material may be separated with the help of the following key:

A. Nutlets strongly constricted just above the base to form a collar. Plants robust, the stems 6.9-11.2 cm tall, densely and coarsely hirsute with spreading to ascending and also appressed whitish hairs or these becoming yellowish in the inflorescence, the longest ones near midstem almost always exceeding 2.3 mm. Larger leaves 7.2-14.7 cm long, 1.4-4 cm wide, the pubescence above ascending, the hairs papillose, those between the veins beneath clearly of two kinds, with a few long and ascending and most short and appressed. . . . . *ONOSMODIUM MOLLE* ssp. *HISPIDISSIMUM*

AA. Nutlets rounded at the base, not constricted into a collar. Plants smaller, the stems (2.6-) 4.8-10.5 cm tall, canescent, both densely hirtellous with appressed hairs and finely hirsute with ascending to spreading hairs, these pure

white or occasionally slightly yellowish, the longest ones near midstem never exceeding 2.2 mm. Larger leaves (4.8-) 5.2-9.1 cm long, 1-2.6 cm wide, the pubescence spreading and papillose to ascending or appressed and scarcely papillose, the hairs between the veins beneath typically softer, much denser and more uniform, mostly subascending to erect. . . . .
. . . .*ONOSMODIUM MOLLE* ssp. *OCCIDENTALE*

ACKNOWLEDGMENTS

I wish to thank Dr. Gary J. Breckon, Dr. Hugh H. Iltis, and Mr. James L. Sawyer for reading the manuscript and commenting on it.

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ADDENDUM

After having completed this manuscript I became aware of the work of Teki L. Das through annotations on specimens in the University of Michigan Herbarium. Dr. T. M. Barkley of Kansas State University, Manhattan, kindly sent me a copy of Das' unpublished M.S. thesis on *Onosmodium,* a valuable study which contains detailed descriptions of nine species and varieties and reviews the intergradient forms of the *O. molle* complex. Das' treatment, in which the category of variety is retained, agrees essentially with that outlined by Cronquist.

Nature education feature --

TEACHING MATERIALS FOR BOTANY CLASSROOMS

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A perennial problem in teaching botany in the cold winter months of the Great Lakes region and northern climates in general is the difficulty in obtaining sufficient useful and interesting flowering plant material for laboratory demonstration and dissection. Standard collections of teaching materials for systematic botany include dried herbarium specimens, flowers and fruits preserved in liquid or dried, and 2 x 2 slides. Living material is usually scanty or lacking altogether.

PRESERVED MATERIAL

The use of carefully prepared herbarium specimens has its merits, particularly in showing the normal sizes of naturally grown plants and in demonstrating certain vegetative features. But, obviously, they are often unappealing and difficult for the student to use in making a first acquaintance with plants. They usually do not preserve color, odor, or three-dimensional shape. In conjunction with herbarium specimens, "pickled" flowers and fruits are somewhat useful in representing 3-D shapes and they can be satisfactorily dissected if they are not too old and mushy. The strong odors of many preservatives are unpleasant. Material preserved in FAA (15 ml ethyl alcohol (95%) : 10 ml distilled water : 1 ml 4% formalin : 1 ml glacial acetic acid) lasts for many years, although it becomes discolored or bleached; and such fluids as Ward's Botanical Preservative (available from Ward's Natural Science Establishment, Rochester, New York) maintain well the green color in plants for several years. This method, too, is unappealing but must be accepted when nothing else is available. For more details on collecting and preserving botanical specimens, in addition to information supplied by many biological supply companies, see Behringer (1973), Fogg (1940), Harrington (1957), Johnston (1939), Ketchledge (1970), Klein and Klein (1970), Knudsen (1966, 1972), Savile (1962), C. E. Smith (1971), H. V. Smith (1973), and Tehon (1966).

2 x 2 SLIDES

In recent years, the use of 2 x 2 slides has played an important role in botanical teaching, especially in lectures. It has proved particularly rewarding at The University of Michigan, where we have brought them into extensive use in the systematic botany laboratories. Slides, some 500 of them, were gathered to show the important features, both habits and structural details, of

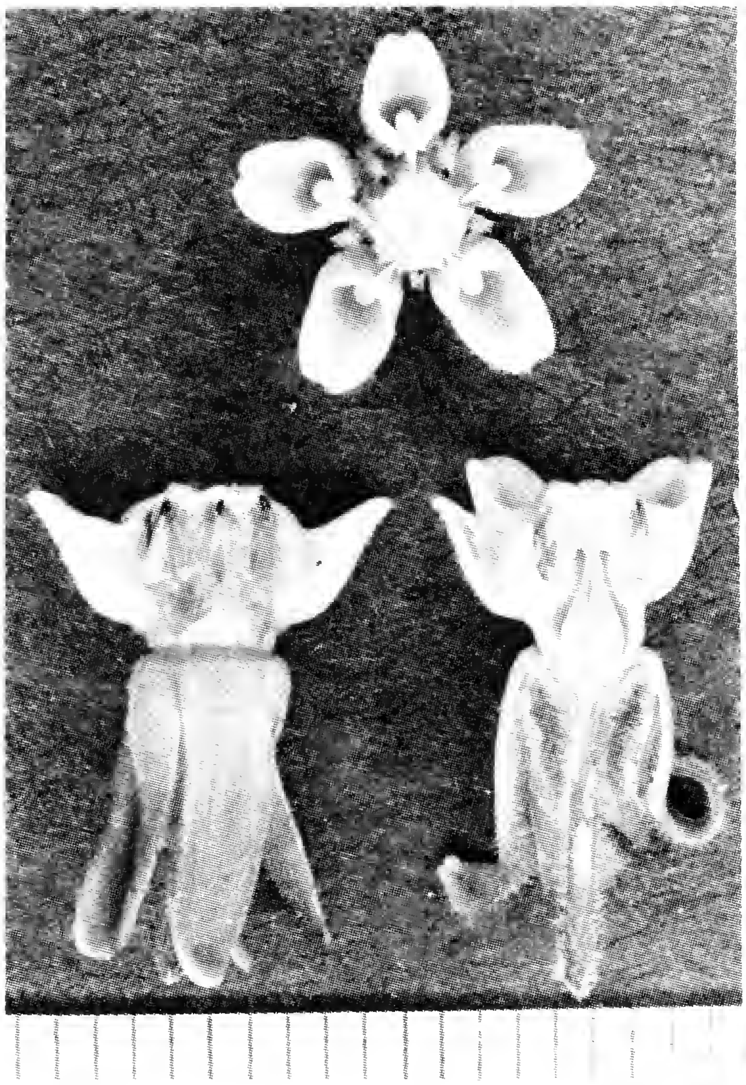
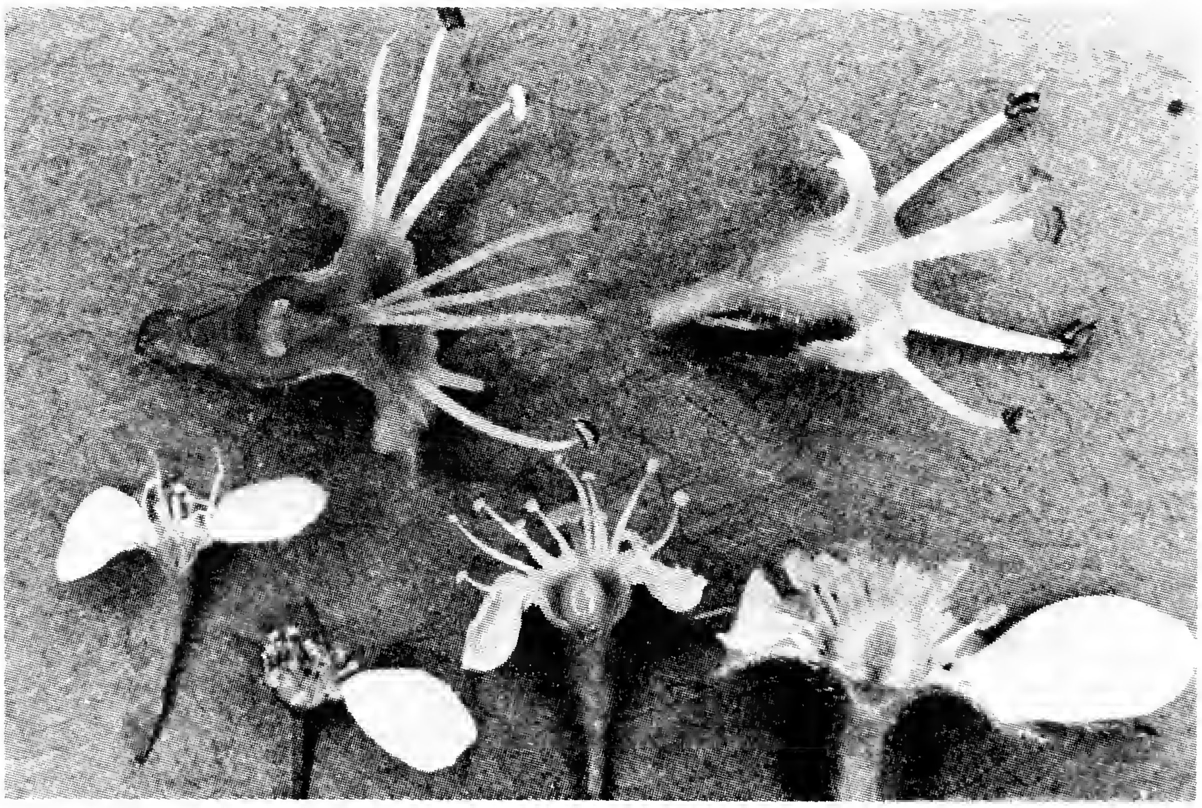


Fig. 1 (left). Dissection of *Asclepias syriaca* (Common Milkweed), with mm scale at bottom. ×3.0.

Fig. 2 (right). Male plants of *Arceuthobium pusillum* (Dwarf Mistletoe), in flower, on Black Spruce. No. 2 insect pin and the spruce needles suggest scale. ×2.5

Fig. 3 (below). Partly dissected flowers of representative members of the four subfamilies of the Rosaceae (Rose family). ×2.5



the plant families and genera covered in the course, including pteridophytes, gymnosperms, and flowering plants. After initial explanation by the instructors, the slides are available for student review at all times. They have been very well received by both students and instructors. The slides have the advantages of showing accurate colors, shapes, and diagnostic features clearly; and a close-up picture of a flower can be shown and explained to the whole class at once (Figs. 1-3). Projection slides also make repetitive viewing and learning easier. The main disadvantages are that they often give a false impression of natural size of the subject (unless a scale is included in the picture [see Figs. 1 & 2]), the wear and tear of much handling of the slides and the projectors eventually becomes apparent, and the initial expense of procuring slides and projection equipment may be prohibitive. If possible, original slides should be conserved and duplicates made for routine classroom use. Slides are also easily obtained from biological supply companies (though relatively expensive), but the best course of action is to take them yourself if you are at all inclined toward photography. With a little practice and experience, and a reasonably priced 35 mm. camera with close-up lenses (or other close-up devices), good quality custom slides can be made for as little as 10-14¢ each. Readers interested in these techniques should see Angel (1972), Davis (1972), Feininger (1972), Eastman Kodak (1969, 1970), Langford (1973), Schmid (1972), Wells et al. (1976), and other books and articles in popular photography magazines for information on techniques of close-ups, lighting, films, presentation, sources of equipment and supplies, etc. Habit and habitat shots are very useful and desirable for teaching ecological aspects of plants. (See Figs. 4 & 5.)

LIVING MATERIAL

Nothing can surpass the use of living plants in the laboratory (Behringer, 1973, ch. 6-8). At The University of Michigan we use them as much as possible in addition to or instead of non-living material. Very often "day-old" flowers which are quite usable may be obtained from a local florist or funeral parlor. Available kinds often include anemones, chrysanthemums, gladiolus, iris, orchids, roses, snapdragons, tulips, and violets. Even purchase of such plants may be less expensive than trying to grow a few of them in the absence of adequate facilities. Fresh-frozen flowering material has proved useful at several institutions (e.g., Rollins, 1950), and of course must be collected during the flowering season. Experimentation is recommended to determine which species have flowers that freeze well and which procedures are most satisfactory. At many colleges and universities, vegetative and flowering material is usually available from various tropical and subtropical plants grown in greenhouses. The most generally available plants include such large, predominantly woody, genera as

Fig. 4 (left). Habit view of *Cirsium pitcheri* at Sturgeon Bay dunes, Emmet Co., Michigan, 17 July 1972. ×0.08

Fig. 5 (below). Habitat of *Cirsium pitcheri* at Sturgeon Bay dunes, with class from University of Michigan Biological Station, 5 July 1971.

(All photos by the author, from 35 mm slides.)

Acacia (Fabaceae)[1]
Allamanda (Apocynaceae)
Annona (Soursop, Annonaceae)
Aristolochia (Dutchman's-Pipe, Aristolochiaceae)
Bambusa (Bamboo, Poaceae)
Bougainvillea (Nyctaginaceae)
Cacti (Cactaceae)
Calliandra (Powder Puff, Fabaceae)
Citrus (Rutaceae)
Coffea (Coffee, Rubiaceae)
Cycads (Cycadaceae)
Ephedra (Mormon Tea, Gnetaceae)
Eucalyptus (Myrtaceae)
Euphorbia (Euphorbiaceae)
Ficus (Fig, Moraceae)
Fuchsia (Onagraceae)
Hedera (English Ivy, Araliaceae)
Hibiscus (Malvaceae)
Musa (Banana, Musaceae)
Nerium (Oleander, Apocynaceae)
Palms (Arecaceae)
Passiflora (Passion Flower, Passifloraceae)
Pereskia (Cactaceae)
Persea (Avocado, Lauraceae)
Piper (Pepper, Piperaceae)
Solanum (Nightshade, Solanaceae)

There are also many greenhouse-grown herbaceous perennials which can be permanently maintained and which provide good flowering and/or vegetative material. Some of these plants may flower continuously while others are definitely seasonal; and in some cases, notably *Ornithogalum caudatum* and *Allium tuberosum*, continuous availability of flowers can be insured by providing a succession of plants of different ages. In the following list, those plants marked * are most useful as vegetative specimens, but may also provide good flowers.

Acanthaceae (various genera such as *Aphelandra, Fittonia, Jacobinia*) [bracteate inflorescences]
**Agave* (Agavaceae) [Succulent]
Aglaonema (Araceae) [Good inflorescences on older plants]
Alisma (Water-plantain, Alismataceae) [Seasonal: Spring-late summer]
Allium (Onion, Amaryllidaceae) [Continuous flowers]
Amaryllis (Amaryllidaceae) [Forced from bulb]
Amomum (Cardamon ginger, Zingiberaceae) [Older plants flower well]
**Anacharis* (Elodea, Hydrocharitaceae) [Sporadic flowering]
Anthurium (Araceae) [Flowers continuously, good inflorescences]
Asclepias curassavica [Milkweed, Asclepiadaceae) [Excellent flowers continuously]
**Asparagus* (Various species, Liliaceae) [Cladophylls]
Begonia (Begoniaceae) [Some cultivars flower continuously]
*Bromeliaceae (Various genera) [Epiphytic habit; seasonal flowers]
Butomus (Flowering-rush, Butomaceae) [Seasonal: late winter-fall]
**Coleus* (Lamiaceae) [Flowers small, but abundant]
**Crassula* (Crassulaceae) [Seasonal flowers; leaf succulent]
**Cyperus* (Sedge, Cyperaceae) [Continuous flowering]
Dichromena (White-bracted Sedge, Cyperaceae) [Continuous flowering; insect pollinated]
**Dionaea* (Venus Fly-trap, Droseraceae) [Seasonal flowers; June. Needs winter dormancy]
Dorstenia (Moraceae) [Continuous flowers; interesting inflorescences]
**Drosera* (Sundew, Droseraceae) [*D. binata* flowers continuously; others need winter dormancy for summer flowering; or

[1]Throughout this article, the following format is used in plant lists: generic name, followed in parentheses by a common or English name, if it is different from the generic name; then the family name. Cultivar names are in single quotation marks (' '). Nomenclature follows Bailey (1949) where applicable, with the exception of authorized alternative family names based on generic names: Apiaceae (Umbelliferae), Arecaceae (Palmae), Asteraceae (Compositae), Brassicaceae (Cruciferae), Fabaceae (Leguminosae), Lamiaceae (Labiatae), and Poaceae (Gramineae).

forced flowering under artificial lights]

Eleocharis (Spike-rush, Cyperaceae) [Continuous flowering]

Fuchsia (Onagraceae) [Continuous flowering; good for dissection]

Gesneriaceae (Various genera) [Mostly seasonal flowering except *Saintpaulia* (African Violet)]

Juncus (Rush, Juncaceae) [Continuous flowering]

**Lithops* (Living-stones, Aizoaceae) [Mimicry succulent; seasonal flowering–fall]

**Nymphaea* (Water-lily, Nymphaeaceae) [Seasonal flowering; summer]

Orchidaceae (Various genera) [Most cultivated types are seasonal; *Habenaria repens* continuous flowering]

Ornithogalum (False Sea-onion, Liliaceae) [Continuous flowering]

**Oxalis* (Sorrel, Oxalidaceae) [Periodic flowering]

**Pelargonium* (Geranium, Geraniaceae) [Good for stem anatomy]

Pentas (Rubiaceae) [Continuous flowering; pollen tubes visible on stigmas]

Peperomia (Piperaceae) [Continuous flowering; highly reduced flowers]

Pilea (*P. microphylla* = Artillery Plant, Urticaceae) [Forcible pollen discharge]

Rhoeo (Moses-in-a-Boat, Commelinaceae) [Continuous flowering]

**Ruscus* (Butcher's-broom, Liliaceae) [Cladophylls]

**Sarracenia* (Pitcher plant, Sarraceniaceae) [Seasonal flowering: Spring; needs winter dormancy]

**Saxifraga sarmentosa* (Strawberry-begonia, Saxifragaceae) [Seasonal flowering: Winter-Spring; vegetative reproduction by runners]

**Scirpus* (Bulrush, Cyperaceae) [Seasonal flowering: Summer]

**Sedum* (Stonecrop, Crassulaceae) [Leaf succulent]

Solanum (Various species, especially *S. seaforthianum* (vine) and *S. pseudocapsicum* (Jerusalem-Cherry), Solanaceae) [Continuous flowering and fruiting]

Spathiphyllum (Araceae) [Continuous flowering]

**Stapelia* (Carrion-flower, Asclepiadaceae) [Stem succulent]

Tradescantia (Spiderwort, Commelinaceae) [Continuous flowering especially in *T. paludosa*]

Vinca rosea (Periwinkle, Apocynaceae) [Continuous flowering and fruiting; very good]

Zebrina (Wandering-jew, Commelinaceae) [Continuous flowering]

Sium suave (Water Parsnip, Apiaceae) [Seasonal flowering: Late winter-fall; good vegetatively for sheathing petioles.]

In addition to these greenhouse perennials, many herbaceous flowering plants can be maintained with a minimum of space (e.g., small greenhouse or sunny window area) by forcing wild plants as pot plants and growing garden flowers from seed.

FORCING WILD PLANTS

Since there is little discussion of forcing wild plants or growing plants from seed in the literature (Pohl, 1964; Rosendahl, 1914), much is left to individual trial-and-error and many teachers may have been reluctant to try it. It will be necessary to judge whether the results warrant the effort, and the latter will depend in part on the ease of obtaining and maintaining the material until used. Wild perennials can be collected early in the season and allowed to "become established" in pots, wooden flats, or plastic trays during the remainder of the growing season; or they can be collected late to avoid disturbing them during their reproductive phase. I prefer to dig them late, often when already dormant, keep them outside until just before hard freezes in the fall, move them into a cold room held at 34-45°F (1-7°C), or cold frame, until the appropriate time [see Table I], then move them into a warm greenhouse (65-70°F days, 60°F nights) and give them extra light. Early

TABLE I. Wild perennials forced into flower.

Plant	Date into Greenhouse	Forcing Time (Weeks)	Comments
Anemonella thalictroides (Windflower, Ranunculaceae)	Jan 1	3-4	Forces well.
Aquilegia canadensis (Columbine, Ranunculaceae)	Dec 1	4-6	Many flowers produced.
Arisaema triphyllum (Jack-in-the-Pulpit, Araceae)	Mar 1	4	Forces well.
Barbarea vulgaris (Winter-cress, Brassicaceae)	Dec 1	4-6	Dig rosettes in fall.
Capsella bursa-pastoris (Shepherd's-Purse, Brassicaceae)	Dec 1	4-6	Dig rosettes in fall.
Carex pensylvanica (Sedge, Cyperaceae)	Feb 1	3	Forces well.
Caulophyllum thalictroides (Blue Cohosh, Berberidaceae)	Dec 1	4-5	Good flowers.
Claytonia virginica (Spring Beauty, Portulacaceae)	Jan 1	3-4	Often brought in with other woodland plants. Weak plants.
Daucus carota (Wild Carrot, Apiaceae)	Dec 1	6	Dig rosettes in fall.
Fragaria virginiana (Strawberry, Rosaceae)	Jan 1	4	Long-lasting flowers.
Galium concinnum (Bedstraw, Rubiaceae)	Feb 1	4-5	Small, numerous flowers.
Geranium maculatum (Wild Geranium, Geraniaceae)	Jan 1	4-6	Good flowers and fruits if pollinated.
Hepatica acutiloba (Liverleaf, Ranunculaceae)	Jan 1	3	No flowers second year.
Jeffersonia diphylla (Twinleaf, Berberidaceae)	Dec 1	4-6	Flowers well, but too few and short-lived.
Mentha piperita (Peppermint, Lamiaceae)	Jan 1	8	Weak growth.
Mitella diphylla (Bishops-cap, Saxifragaceae)	Jan 1	4-5	Forces well.
Monarda fistulosa (Wild Bergamot, Lamiaceae)	Jan 1	8	Good flowers; weak growth.
Nepeta cataria (Catnip, Lamiaceae)	Jan 1	6-8	Good flowers; weak growth.
Parnassia glauca (Grass-of-Parnassus, Saxifragaceae)	Feb 1	8	Good flowers produced for a very long time.
Phytolacca americana (Pokeweed, Phytolaccaceae)	Dec 1	6	Large plant; good flowers & fruits; does not do well year after year.
Plantago spp. (Plantain, Plantaginaceae)	Dec 1	4-6	Dig rosettes in fall.
Podophyllum peltatum (May-apple, Berberidaceae)	Dec 1	4-5	Forces well, few flowers.
Potentilla recta (Cinquefoil, Rosaceae)	Dec 1	6	Dig rosettes in fall; long-flowering.
Ranunculus septentrionalis (Swamp Buttercup, Ranunculaceae)	Jan 1	5-6	Forces well and early.

TABLE 1 (Continued).

Plant	Date into Greenhouse	Forcing Time (Weeks)	Comments
Rumex acetosella (Sheep Sorrel, Polygonaceae)	Jan 1	4-5	Dig rosettes in fall; weak plant.
Sanguinaria canadensis (Bloodroot, Papaveraceae)	Feb 1	2	Forces well; keep from drying out.
Smilax tamnoides (Greenbriar, Liliaceae)	Feb 1	5	Vegetative only.
Stellaria pubera (Giant Chickweed, Caryophyllaceae)	Jan 1	4	Large flowers; native farther south.
Thalictrum dioicum (Early Meadow-rue, Ranunculaceae)	Dec 1	4-5	Get ♂ and ♀ plants.
Trifolium pratense (Clover, Fabaceae)	Jan 1	6	Forces poorly.
Urtica dioica (Stinging Nettle, Urticaceae)	Feb 1	3	Vegetative only.
Viola papilionacea (Purple Violet, Violaceae)	Jan 1	4	Forces well.

Species which gave poor results, i.e. no flowers and little growth, were *Dicentra* spp. (Fumariaceae), *Hypericum perforatum* (Hypericaceae), *Phlox divaricata* (Polemoniaceae), and *Trillium grandiflorum* (Liliaceae).

spring wildflowers with ephemeral leaves should be dug in June while their leaves are still evident, or marked so that they can be found later in the fall. A thorough cold period seems imperative for good forcing results, especially with plants kept over several years; and the extra light is probably necessary to break photoperiodic restrictions on dormancy in many plants. Some regular fertilizing may also prove beneficial.

Some plants have forced well for us, and others have not. There can be quite a bit of variation in a given species from year to year, regardless whether new plants are dug each season or old ones kept for several years. In some cases (e.g., *Anemonella, Aquilegia, Arisaema, Carex, Fragaria, Thalictrum, Viola*) we have forced the same specimens very successfully now for four years, repotting after two years. *Aquilegia* also sets seeds very readily and many young plants come up in other pots and flower the following year after a good season's growth.

In Table I, the species are given with the date they were brought into the greenhouse from the cold room and the approximate length of time (in weeks) required before the first flowers are produced. One has to be liberal with time when setting up a forcing schedule, as many factors are involved in the forcing of plants. Generally, the cooler and slower the forcing, the better the results. In most cases, many flowers are produced over a period of days or weeks, and several pots may be prepared and brought in at intervals to insure flowers at the proper time. As the plants begin to flower, they may be held in a lighted cold room or cool greenhouse until needed.

PLANTS FROM SEEDS

In growing plants from seeds, it is best to use horticultural annuals, as they are easiest to flower from seed in a short time (e.g., annual poppy instead of Iceland poppy). Some seeds need to be started early in the fall, or late summer, for plants to produce flowers in late winter. Often it is a good idea to start plants at intervals to ensure flowering material over a long period of time. Some plants flower almost continuously, however, such as phlox 'Twinkle,' sage, snapdragon, stock, and sweet pea. Another point to remember is to use single-flowered, "normal" varieties, since doubled portulaca and "butterfly" snapdragons do not make usable teaching specimens. We have found it better to stick to the old standard varieties, when available, as sometimes the fancy cultivars do not grow or flower so well throughout the winter.

Table II indicates the plants which we have grown from seeds under standard greenhouse conditions over the past two years, or longer for some species. Most of the seeds can be ordered from the W. Atlee Burpee Seed Co., Warminster, Pa. 18974 and G. W. Park Seed Co., Greenwood, S.C. 29647.

TABLE II. Plants grown from seeds.

Plant	Date Seed Sown	Months to Flower	Comments
Agrostemma (Corn-cockle, Caryophyllaceae)	Sept 1	5-6	Large flowers; late.
*Amaranthus (Pigweed, Amaranthaceae)	Nov 1	3	Pot spontaneous seedlings from greenhouse bench.
*Antirrhinum (Snapdragon, Scrophulariaceae)	Nov 1	3-4	Copious flowering.
Borago (Boraginaceae)	Nov 1	4-5	Good flowers.
*Avena (Oats, Poaceae)	Jan 1	3-4	Good grass flower.
Browallia (Solanaceae)	Nov 1	5	Copious flowering.
*Celosia argentea 'Plumosa' (Amaranthaceae)	Nov 1	3	Flowers rarely formed among the bracts.
*Celosia argentea 'Cristata' (Cock's-comb, Amaranthaceae)	Nov 1	3	Good fasciation.
*Chenopodium (Lambs-quarters, Chenopodiaceae)	Nov 1	3	Pot from bench seedlings.
*Convolvulus (=Ipomoea) (Morning-glory, Convolvulaceae)	Dec 1	4	Good flowers.
*Cucurbita (Squash, Cucurbitaceae)	Nov 1	3-4	Plants monoecious.
*Cynoglossum nervosum (Hounds-tongue, Boraginaceae)	Oct 1	4-5	Copious flowering; hand pollinate for good fruits.
Datura (Jimson-weed, Solanaceae)	Dec 1	2-3	Flowers open at night.
*Dianthus (Pink, Caryophyllaceae)	Sept 1	4-5	Copious flowering.

TABLE II (Continued).

Plant	Date Seed Sown	Months to Flower	Comments
Didiscus (Blue Lace Flower, Apiaceae)	Sept 1	5-6	Good umbels; atypical vegetatively.
*Fagopyrum esculentum (Buckwheat, Polygonaceae)	Dec 1	2-3	Good flowers and fruits.
*Foeniculum (Fennel, Apiaceae)	Sept 1	6-8	Bring in old garden plants for earlier flowering.
*Euphorbia heterophylla (Fire-plant, Euphorbiaceae)	Aug 20	6-8	Good flowers.
Gypsophila (Baby's-breath, Caryophyllaceae)	Sept 1	3-5	Copious flowering; use large-flowered variety.
*Helianthus annuus (Sunflower, Asteraceae)	Dec 1	4	One flower per plant; good flower and fruit.
*Iberis umbellata (Candytuft, Brassicaceae)	Oct 1	4-5	Good flowers and fruit.
*Lathyrus (Sweet Pea, Fabaceae)	Nov 1	3	Several plants in large tub with room to climb produce abundant flowers continuously.
Linaria (Butter-and-eggs, Scrophulariaceae)	Dec 1	3-4	Good flowers.
*Matthiola incana (Stock, Brassicaceae)	Sept 1	5-6	Our best crucifer flower; large flowers and fruits.
Nicotiana (Flowering Tobacco, Solanaceae)	Nov 1	4	Large tubular flowers.
*Panicum (Ornamental Grass, Poaceae)	Jan 1	3-4	Flowers do not last long.
*Papaver commutatum (Annual Poppy, Papaveraceae)	Aug 20	7-8	Needs plenty of extra light to flower early.
Petunia (Solanaceae)	Nov 1	6	Copious flowering
*Phaseolus (Bean, Fabaceae)	Jan 1	2	Start at intervals to have flowers and fruits.
*Phlox 'Twinkle' (Polemoniaceae)	Oct 1	3-6	Copious flowering.
*Pisum sativum (Pea, Fabaceae)	Jan 1	2	Start at intervals to have flowers and fruits.
*Polygonum orientale (Prince's-feather, Polygonaceae)	Nov 1	4	Large flowers and okrea.
*Portulaca grandiflora (Rose-moss, Portulacaceae)	Sept 1	4-6	Needs extra warmth to flower well and early.
Salpiglossis (Solanaceae)	Sept 1	6-7	Good flowers.
*Salvia splendens (Scarlet Sage, Lamiaceae)	Nov 1	3-4	Copious flowering; large flowers.
Schizanthus (Butterfly-flower, Solanaceae)	Nov 1	4	Interesting stamen-snapping mechanism.
*Zea mays (Corn, Poaceae)	Jan 1	3	Plants remain small, and still bear fruit, if kept in small pots.
Zinnia (Asteraceae)	Dec 1	3-4	Useful if not too doubled.

*Particularly dependable and useful.

Included in the list is the plant name, usually genus only, except where the species helps distinguish an especially useful type; and common, or cultivar, name, which can be easily found in a seed catalogue. The names may be checked in Bailey's Manual (1949) for more information on the species. Following the name comes the approximate date on which we started the seeds, then the usual length of time to first flowering (in months), and comments. There can be much variation in forcing time and flower quantity and quality from year to year, depending, we suspect, on type and age of seed, number of bright, sunny days in the fall and winter when the plants are growing, repotting and fertilizing schedule, etc. In some cases, if the plant flowers much too early, it can be cut back and forced to send up new flowering shoots. This works well with browallia, dianthus, flowering tobacco, lambs-quarters, phlox, polygonum, sage, stock, snapdragon, and some others which are known to be branched and "ever-blooming." Those marked (*) are most highly desirable and useful, although some, particularly *Papaver commutatum,* are not consistent in flowering on time but are definitely worth trying anyway (they usually flower a little late). For standard techniques of growing plants from seed, see Haring (1967).

To give some idea of the potential extent of use of living material in the botany classroom, the following charts are given. The data are based on the Systematic Botany course taught at The University of Michigan in winter, 1974, in which 107 families and 173 genera (included in those families) of flowering plants were required for recognition. 91% of the families and 71% of the genera were represented by living material.

Sources of Lab Materials for 107 Families

Living Material

30	families represented exclusively from conservatory and greenhouse collections
6	families represented exclusively from forced wild plants
11	families represented exclusively from plants grown from seeds
6	families represented exclusively from forced twigs of woody plants (Mellichamp, 1976)
44	families represented from more than one of the above categories
97	Subtotal of families represented by living material = 91% of total number of families.

Sources of Lab Materials for 173 Genera

Living Material

44	genera represented exclusively from conservatory and greenhouse collections
29	genera represented exclusively from forced wild plants
20	genera represented exclusively from plants grown from seeds
31	genera represented exclusively from forced twigs of woody plants
123	Subtotal of genera represented by living material = 71% of total number of genera.

ACKNOWLEDGMENTS

This project grew out of a desire for better demonstration material, especially living material, in the laboratory while I was serving as a teaching assistant in Professor Warren H. Wagner's Systematic Botany course at The University of Michigan. I thank him for inspiration and offering suggestions. He also gave impetus for the development of the teaching slide collection. I wish also to thank Mr. Louis Ludwig for his help and advice on growing plants from seed; Dr. Thomas Morley of the University of Minnesota at St. Paul for providing me with the reference by Pohl; Dr. Sylvia Taylor for some original collections of wild perennials; Dr. E. G. Voss for criticizing the manuscript and suggesting certain references on specimen preservation; and the University of Michigan Matthaei Botanical Gardens staff for their cooperation and tolerance during the project. In this respect, Mr. Keith Kraetzer deserves special credit for handling seed propagation and associated data collecting during the 1974-75 season. Finally, I would like to thank my wife, Audrey, for accompanying me on many photographic field trips and errands to the Botanical Gardens at all wee hours of the night to check on the plants during critical forcing times.

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Savile, D. B. O. 1962. Collection and Care of Botanical Specimens. Canada Dep. Agr. Publ. 1113. 124 pp.

Schmid, Rudolf. 1971. Close-up photography of flowers with flash. Am. Orchid Soc. Bull. 40: 232-243.

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MICHIGAN PLANTS IN PRINT
New Literature Relating to Michigan Botany

A. MAPS, SOILS, GEOLOGY, GENERAL

Hansen, Edward A. 1975. Does Canoeing Increase Streambank Erosion? U.S. Dep. Agr. North Central For. Exp. Sta. Res. Note NC-186. 4 pp. [Study on Pine River in Michigan indicated that heavy canoe traffic was not a cause of erosion, but "people sliding and camping on streambanks created some erosion"; certain eroding banks identified in 1966 were naturally revegetating in 1973 despite a fivefold increase in canoe traffic.]

Hathaway, Richard J. 1975. Mapping Michigan: Writers and Collectors. Michigan in Books 13(2): 6-11. [Notes on collections and bibliographies of Michigan maps, with reproductions of a 1672 Jesuit map of Lake Superior and Bellin's 1744 "Lacs du Canada"–one of the first representations of all five Great Lakes with their present names. This special issue of Michigan in Books (free from State Library, 735 E. Michigan Ave., Lansing 48913) also has an article on making the annual transportation map, information on sources of maps, and reproduction of an 1839 Michigan map on the cover.]

Hendrickson, G. E., & C. J. Doonan. 1974. Reconnaissance of the Upper Au Sable River, a Cold-Water River in the North-Central Part of Michigan's Southern Peninsula. U.S. Geol. Surv. Hydrol. Invest. Atlas HA-527. 1 sheet. $1.00. [Another report in the series previously noted here, dealing with the channel, bank vegetation, and stream characteristics between Grayling and Wakeley Bridge.]

Huber, N. King. 1975. The Geologic Story of Isle Royale National Park. U.S. Geol. Surv. Bull. 1309. 66 pp. $1.20. [A summary of bedrock and surface features, well illustrated with photos, maps, and diagrams; even a brief reference to the remarkably disjunct *Oplopanax*.]

Raymond, Randall E., Ronald O. Kapp, & Robert A. Janke. 1975. Postglacial and recent sediments of inland lakes of Isle Royale National Park, Michigan. Mich. Academ. 7: 453-465. [Relates cores from 12 sites to lakes Minong and Nipissing and the low-water Lake Houghton stage.]

Say, E. W., M. W. Paddock, J. E. Gannon, & W. L. Foster. 1975. Inland Lake Protection in Northern Michigan. Univ. Mich. Biol. Sta. N. Mich. Env. Res. Prog. Educ. Ser. Publ. 1. 40 pp. [A broad survey (hardly "in depth" though described in that trite phrase) of environmental concepts, lake origins and problems, watersheds and their management, and means of citizen involvement, with special reference to the "Inland Water Route Region"–chiefly the Cheboygan River watershed, which is mapped on p. 2.]

Tallman, Robert J. 1975. Epilimnion circulation in North Fishtail Bay, Douglas Lake, Michigan. Mich. Academ. 7: 397-408. [Includes information on currents, sedimentation, and shoreline morphology, with aerial photos of Hook Point and East Point.]

B. BOOKS, BULLETINS, SEPARATE PUBLICATIONS

Coffman, Michael S. 1975. Tsuga canadensis (L) Carr. Germination Stimulated by Red Light While Inhibited by Gibberellin and Kinetin. Mich. Tech. Univ. Ford For. Ctr. Res. Note 13. 12 pp. [Source of seed was near Houghton.]

Hesler, L. R. 1969. North American Species of Gymnopilus. Mycologia Mem. 3. 117 pp. [Many of the species are cited from Michigan, without further locality data except for the types of 6 new species.]

Hickey, William O., & Thomas A. Leege. 1970. Ecology and Management of Redstem Ceanothus A Review. Idaho Fish Game Dep. Wildl. Bull. 4. 18 pp. [Map of regions in which *C. sanguineus* is present indicates the entire Lower Peninsula, in none of which this species occurs; on the other hand, it *is* found on the Keweenaw Peninsula but is not mapped there–despite correct information supplied to the authors when they requested it for this purpose.]

Lloyd, Robert M. 1971. Systematics of the Onocleoid Ferns. Univ. Calif. Publ. Bot. 61.

93 pp. [*Matteuccia struthiopteris* cited from 2 Michigan counties and *Onoclea sensibilis* from 1; Michigan material used for morphological studies of both these species, but no locality data cited.]

Shetron, Stephen G. 1975. A Comparison of Three Species of Pines in Stands of Native and Plantation Origin. Mich. Tech. Univ. Ford For. Ctr. Res. Note 15. 8 pp. [Includes height, age, and basal area comparisons for native stands on 9 soil series at unspecified sites on State Forest lands in the Upper Peninsula.]

Stearns, Forest, & Nicholas Kobriger. 1975. Environmental Status of the Lake Michigan Region Vol. 10. Vegetation of the Lake Michigan Drainage Basin. Argonne Natl. Lab. 113 pp. $5.45 (ANL/ES-40 Vol. 10, from NTIS). [Many Michigan references; see review in Mich. Bot. 14: 218. Oct. 1975.]

Willis, Gary L., & Michael S. Coffman. n.d. [1975?]. Composition, Structure, and Dynamics of Climax Stands of Eastern Hemlock and Sugar Maple in the Huron Mountains, Michigan. Mich. Tech. Univ. Dep. For. Tech. Bull. 13. 43 pp.

C. JOURNAL ARTICLES

Anderson, Loran C., Charles D. Zeis, & Shah Faroq Alam. 1975 ["1974"]. Phytogeography and possible origins of Butomus in North America. Bull. Torrey Bot. Club 101: 292-296. [Includes map of native and naturalized distribution in the world, and suggests that plants in the Great Lakes region were introduced from Europe while those in the St. Lawrence region came from Asia–supporting the view (Mich. Bot. 7: 134-142) that our plants represent a different introduction from the others.]

Belling, Alice J., & Calvin J. Heusser. 1975 ["1974"]. Spore morphology of the Polypodiaceae of northeastern North America. I. Bull. Torrey Bot. Club 101: 326-339. [Material described and illustrated of *Woodsia oregana* (Keweenaw Co.) and *Dryopteris cristata* (Kent Co.) came from Michigan collections.]

Bowler, Peter A., & Philip W. Rundel. 1975 ["1974"]. The Ramalina intermedia complex in North America. Bryologist 77: 617-623. [Distribution map shows *R. intermedia* at 4 Michigan localities.]

Carstens, Kenneth C. 1972. Tobico (20BY32), a Late Woodland site in Bay County, Michigan. Mich. Archaeol. 18: 113-168. [Consideration of an aboriginal site in Kawkawlin Tp., including a "Present Day Floral Analysis" of the immediate area; this includes some species not known from Michigan (presumably misidentifications) and is so riddled with misspelled names that one can only hope the archeological data are handled with less carelessness than the botanical.]

Catling, Paul M., & James E. Cruise. 1975 ["1974"]. Spiranthes casei, a new species from northeastern North America. Rhodora 76: 526-536. [Some material previously reported from our region as possibly *S. vernalis* or *S. lacera* × *cernua* is included in the new species, named for Fred W. Case; 5 locations in Michigan are mapped, but a representative specimen is cited from the state only from Marquette Co.]

Crumley, Carole L. 1973. The Kantzler Site (20 By 30); A multi-component Woodland site in Bay County, Michigan. Mich. Archaeol. 19: 183-291. [Includes a chapter on "Floral Remains" listing carbonized acorns and a grape seed as well as wood of oak, hickory, and pine from the site, with some discussion. Also lists "vegetation" (i.e. plant species) typical of the habitat of molluscs found at the site; this list has so many obvious misidentifications, misspellings, and misclassifications (7 species of vascular plants under "Algae") as to be worthless botanically.]

Fitzgerald, Sue, & Robert E. Bailey. 1975. Vegetational characteristics of a circum-neutral bog, Barney's Lake, Beaver Island, Michigan. Mich. Academ. 7: 477-488. [Includes data on plant communities, phenology of species, and Raunkiaer classes; although the scientific names are alleged to have been taken from reputable works, over 40 typographical errors occur in the orthography of names and their authors.]

Ford, Richard I. 1974. Corn from the Straits of Mackinac. Mich. Archaeol. 20: 97-104. [A deposit of corn cobs from a Late Woodland site in northernmost Emmet Co.]

Ford, Richard I., & Volney H. Jones. 1974. Job's Tears, Coix lachryma-jobi., beads from the West Ridge–Gibraltar Site, southeastern Michigan. Mich. Archaeol. 20: 105-111. [First archeological record of this species in the U.S., from southeastern Wayne Co.]

Freeman, John D. 1975. Revision of Trillium subgenus Phyllantherum (Liliaceae). Brittonia 26: 1-62. [Maps in this treatment of the sessile-flowered species show *T. recurvatum* and *T. sessile* only in southwestern Michigan (presumably Berrien Co.); no mention is made of Case and Burrows' 1962 report of *T. viride* from Michigan.]

Gilliam, Martina S. 1975. Marasmius section Chordales in the northeastern United States and adjacent Canada. Contr. Univ. Mich. Herb. 11: 25-40. [Four of the 6 species are cited from Michigan localities.]

Gilliam, Martina S. 1975. New North American species of Marasmius. Mycologia 67: 817-844. [Six of the 9 species are cited from Michigan counties, including the types of all 6.]

Graham, Shirley A. 1975. Taxonomy of the Lythraceae in the southeastern United States. Sida 6: 80-103. [Distribution map for *L. alatum* (including *L. dacotanum*) indicates 7 localities in the southeastern Lower Peninsula.]

Hardin, James W. 1975. Hybridization and introgression in Quercus alba. Jour. Arnold Arb. 56: 336-362. [Hybrid populations of *Q. alba* × *macrocarpa* in Livingston, Lapeer, and Oakland counties were analyzed, and distribution maps show occurrence of this hybrid and others in one or more Michigan counties: *Q. alba* × *bicolor, Q. alba* × *muehlenbergii, Q. alba* × *prinoides.*]

Hattori, Sinske. 1972. Frullania tamarisci-complex and the species concept. Jour. Hattori Bot. Lab. 35: 202-251. [Includes comments on a collection of subsp. *asagrayana* from Marquette Co.]

Haynes, Robert R. 1975 ["1974"]. A revision of North American Potamogeton subsection Pusilli (Potamogetonaceae). Rhodora 76: 564-649. [Of the 8 species recognized, 6 (including 2 vars. of *P. pusillus*) are cited from selected Michigan localities and mapped in the state (too boldly to determine localities or counties); contains keys and descriptions, some field observations from Michigan.]

Hoseney, Florence V. 1975. Fungus collections from the E. S. George Reserve, Livingston County, Michigan. Beih. Nova Hedwigia 51: 145-162. [A list of nearly 500 species thus far identified from the area, with collectors and numbers indicated.]

Johnson, Wendel J. 1970. Food habits of the red fox in Isle Royale National Park, Lake Superior. Am. Midl. Nat. 84: 568-572. [Includes notes on 7 plants of which ripe fruit is included in the fox diet.]

Loomis, Robert M. 1975. Diagnostics of northern red oak (Quercus rubra) biomass for predicting fire behavior. Mich. Academ. 7: 515-520. [Includes data on oven-dry weights of branchwood on trees from two locations in the Manistee National Forest.]

Maeglin, Robert R., & Lewis F. Ohmann. 1974 ["1973"]. Boxelder (Acer negundo): A review and commentary. Bull. Torrey Bot. Club 6: 357-363. [Mentions that individuals in southeastern Michigan have been observed (by whom?) producing much seed at 15 years of age.]

Mahler, Wm. F. 1975. Typification and distribution of the varieties of Gnaphalium helleri Britton (Compositae–Inuleae). Sida 6: 30-32. [Distribution maps show var. *micradenium,* formerly associated with *G. obtusifolium,* in 7 Michigan counties from Huron and Bay to Cheboygan, in northeastern Lower Peninsula.]

Moss, Brian. 1973. Diversity in fresh-water phytoplankton. Am. Midl. Nat. 90: 341-355. [A study of seasonal changes in two British lakes and Gull Lake, Kalamazoo Co.]

Petersen, Ronald H. 1975. Notes on Cantharelloid fungi. V. A new species of *Cantharellus.* Beih. Nova Hedwigia 51: 183-190. [One collection of the new *C. ignicolor* cited from Marquette Co.]

Prahl, Earl J. 1974. The Morin Site (20 MO 40), Monroe County, Michigan. Mich. Archaeol. 20: 65-95. [Includes map of presettlement vegetation around the western end of Lake Erie (Ohio and Michigan) and report of floral remains at a 7th-8th Century site, including corn, hickory, black walnut, hazelnut, and chenopodium seeds.]

Schultz, Janet. 1976 ["1975"]. A seasonal study of feeding of birds on four species of dogwood, Cornus sp., in Michigan. Mich. Academ. 8: 207-221. [Research in Isabella Co.]

Shaffer, Robert L. 1975. Some common North American species of Russula, subsect. Emeticinae. Beih. Nova Hedw. 51: 207-237. [Six of the 7 species are cited from Michigan localities, including the type of one new one.]

Southall, Russell M., & James W. Hardin. 1974. A taxonomic revision of Kalmia (Ericaceae). Jour. Elisha Mitchell Sci. Soc. 90: 1-23. [Generalized distribution maps show *K. angustifolia* and *K. polifolia* ranging into Michigan; key and descriptions but no specimen citations.]

Sparrow, F. K. 1975. Observations on Chytridiaceous parasites of phanerogams. XXIII. Notes on Physoderma. Mycologia 67: 552-568. [Consists entirely of discussion of 6 taxa found on various hosts in vicinity of the University of Michigan Biological Station, with detailed localities cited in Emmet, Cheboygan, Charlevoix, and Mackinac cos.]

Steere, William Campbell. 1975. Occurrence of Entodon cladorrhizans in Alaska, with notes on geographical distribution of E. concinnus. Bryologist 78: 334-342. [An 1896 report of *E. concinnus* from southern Michigan is assumed to be an error for *Pleurozium schreberi.*]

Taylor, Jane, Peggie J. Hollingsworth, and Wilbur C. Bigelow. 1974. Scanning electron microscopy of liverwort spores and elaters. Bryologist 77: 281-327. [Material of *Blasia pusilla* came from Michigan; some of the photos previously appeared in Mich. Bot. 12: 131. 1973.]

Vitt, Dale H., & Nancy G. Slack. 1975. An analysis of the vegetation of Sphagnum-dominated kettle-hole bogs in relation to environmental gradients. Canad. Jour. Bot. 53: 332-359. [Study of 8 bogs in Chippewa, Mackinac, Emmet, and Cheboygan cos.]

Wells, Virginia L., & Phyllis E. Kempton. 1975. New and interesting fungi from Alaska. Beih. Nova Hedwigia 51: 347-358. [*Baeospora myriadophylla* also cited from Michigan.]

Werner, Patricia A. 1975. The biology of Canadian weeds 12. Dipsacus sylvestris Huds. Canad. Jour. Pl. Sci. 55: 783-794. [Distribution map shows localities in southern half of Lower Peninsula and in the Keweenaw Peninsula of Michigan.]

D. HISTORY, BIOGRAPHY, EXPLORATION

(Anon.) 1971. Gwen Frostic, Michigan artist. P.E.O. Record 83(11): 15-17. [Brief sketch of Michigan's artist, poet, printer, and lover of all outdoors, an honorary member of the Michigan Botanical Club.]

Jones, Kenneth Lester (compiler). 1975. The Harley Harris Bartlett Diaries. Published and circulated privately by K. L. Jones, Ann Arbor. 323 pp. [This substantial hard-cover book includes not only selections from the diaries of the late Professor Bartlett (with references to associates at the University of Michigan and elsewhere) but also some additional biographical information and correspondence to round out a picture of the extraordinarily versatile and gifted botanist, an honorary member of the Michigan Botanical Club, who died in 1960.]

Wallin, Helen. 1970. Douglass Houghton Michigan's First State Geologist 1837-1845. Mich. Geol. Surv. Pamphl. 1 (rev.). 24 pp. [This pamphlet, available from Publications Room, DNR, Lansing 48926, provides a concise biographical sketch, with many facts, although saying nothing of Houghton's considerable botanical accomplishments (see McVaugh in Mich. Bot. 9: 213-243. 1970).]

Smith, Helen V. 1975. Exploring for mushrooms with A. H. Smith. Beih. Nova Hedwigia 51: 1-24. [An anedcotal, not strictly biographical, account of travels and researches in Michigan and elsewhere, appropriately appearing as the first article in this special 372-page "festschrift" number of the Beihefte: "Studies on Higher Fungi. A Collection of Papers Dedicated to Dr. Alexander H. Smith on the Occasion of his Seventieth Birthday," edited by Howard E. Bigelow and Harry D. Thiers. (Other articles in this number are or will be noted, when relevant to these geographical listings, under their respective authors, among the students and associates of A. H. Smith: Ammirati & Gilliam, Bigelow, Burdsall & Miller, Clémençon, Hoseney, Petersen, Shaffer, Trappe, Wells & Kempton.]

Editorial Notes

ERRATA: In Vol. 15, No. 1 (January 1976), on p. 10, in 7th line of figure legend, for T26N read T25N; on p. 41, in 5th line of footnote 51, for June 17 read June 16.

The January number (Vol. 15, No. 1) was mailed January 19, 1976.

News of Botanists

Paul W. Thompson, Fellow of the Cranbrook Institute of Science and Research Associate in Botany, long active in the Michigan Botanical Club and the Michigan Natural Areas Council, has been made an honorary member of the Southeastern Chapter of the Club. He was also a 1974 recipient of an Oak Leaf Award from the Nature Conservancy "in recognition of especially dedicated service and support toward achieving the Conservancy's objectives."

Warren H. Wagner, Jr., a past president of the Michigan Botanical Club and chairman of the Department of Botany in the Division of Biological Sciences, University of Michigan, was one of five faculty members to receive a U-M Distinguished Achievement Award in 1975 "for outstanding scholarship, teaching, and service."

RECENT DEATHS

Phil DeGraff, honorary member of the Michigan Botanical Club, died November 7, 1975, at the age of 76. Memorial services will be held October 3, 1976, in the chapel he created at Wegwas Lodge, Trout Lake. It was at his resort at Trout Lake (Chippewa County) where the Michigan Botanical Club was founded on May 31, 1941 (under the name of Michigan Wildflower Association). During the more than 40 years that he operated his resort, he emphasized nature trails and studies for his guests.

Henry Allan Gleason, well known taxonomist as well as pioneer ecologist and plant geographer, died April 21, 1975, at the age of 93. He was author of the three-volume *New Britton and Brown Illustrated Flora* (1952) and hence co-author (1963) of Arthur Cronquist's condensation of that work to popular manual size. Many presentday botanists have almost forgotten that Gleason was a member of the University of Michigan botany faculty from 1910 until 1919, when he want to the New York Botanical Garden. He served as director of the U-M Biological Station on Douglas Lake 1913-1915 and of the U-M Botanical Gardens 1915-1919. His *Plants of Michigan,* first published in 1918, has been extremely useful to many local botanists.

William G. Fields, associate professor in the Department of Botany and Plant Pathology, Michigan State University, and president of the Red Cedar Chapter of the Michigan Botanical Club, died on November 30, 1975, in a tragic fire in his apartment.

George W. Gillett, who was very active in the Michigan Natural Areas Council and the Botanical Club during his years (1956-1962) on the botany faculty at Michigan State University, died at the age of 58 in Riverside, California, on January 14, 1976.

Fred W. Rapp, veteran botanist of Kalamazoo County, died in Three Rivers, Michigan, at the age of 96 on November 9, 1975. He had lived almost all his life in the house at Vicksburg where he was born September 28, 1879. An avid naturalist, he explored extensively near Vicksburg. In 1967, he donated his herbarium, consisting of approximately 6000 mounted sheets and 10,000 unmounted ones, to Western Michigan University, where it is kept with the Hanes collection. His extensive collection of bird skins was given to the Kalamazoo Nature Center.

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(On the cover: Wintergreen (Gaultheria procumbens) *appearing through the melting snow near Deer Park, Luce County, Michigan. Photo by Ursula R. Freimarck, March 9, 1974.)*

Vol. 15, No. 3

THE MICHIGAN BOTANIST

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Articles dealing with any phase of botany relating to the Upper Great Lakes Region may be sent to the editor in chief. In preparing manuscripts, authors are requested to follow our style and the suggestions in "Information for Authors" (Vol. 13, p. 190).

THE MICHIGAN BOTANICAL CLUB

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A BOTANICAL INVENTORY OF SANDHILL WOODLOT, INGHAM COUNTY, MICHIGAN I. THE VEGETATION[1]

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Sandhill Woodlot is part of the Water Quality Research Area under the management of the Institute of Water Research, Michigan State University. The 450-acre area is bound by Sandhill Road on the south, College Road on the west, Jolly Road on the north, and Phillips Road on the east. It is the site of a wastewater and nutrient recycling project involving both managed and natural ecosystems with a broad array of soil and vegetation types. Sandhill Woodlot occupies about 44 acres of the south-central portion of the area.

The Woodlot supports a forest dominated by *Acer saccharum, Fraxinus americana, Fagus grandifolia, Prunus serotina,* and *Ulmus* spp. A well developed canopy throughout most of the woods shades the forest floor after full leaf expansion. Understory woody growth consists primarily of saplings of the major tree species with *Acer saccharum* saplings being the most abundant. A large proportion of the *Ulmus americana* present are saplings which have grown since the initial Dutch Elm Disease epidemic in the 1960's. A majority of the dead trees and decaying logs found throughout the woods are of this species. Although shrubs and vines are abundant in some portions of the woods, they are only a secondary component of the total woody understory. The Woodlot supports a rich spring herbaceous flora throughout and a substantial summer herbaceous flora in the moister portions, where aquatic and semi-aquatic plants are also common. A wide variety of fungi and mosses are also abundant.

HISTORY AND ENVIRONMENT

Sandhill Woodlot was purchased by Michigan State University from the Lott and Wieland families in the early 1960's. Many of the trail systems and fence lines established by these families are still present (Fig. 1). The adjacent cultivated fields and pine plantation have since been abandoned.

The Woodlot is located on three major soil types. The drained portions are either Spinks loamy sand or Miami loam. The imperfectly drained portions are Conover soils. Figure 2 is a detailed soils map of the Woodlot taken from a soils map prepared by the Institute of Water Research, Michigan State University.

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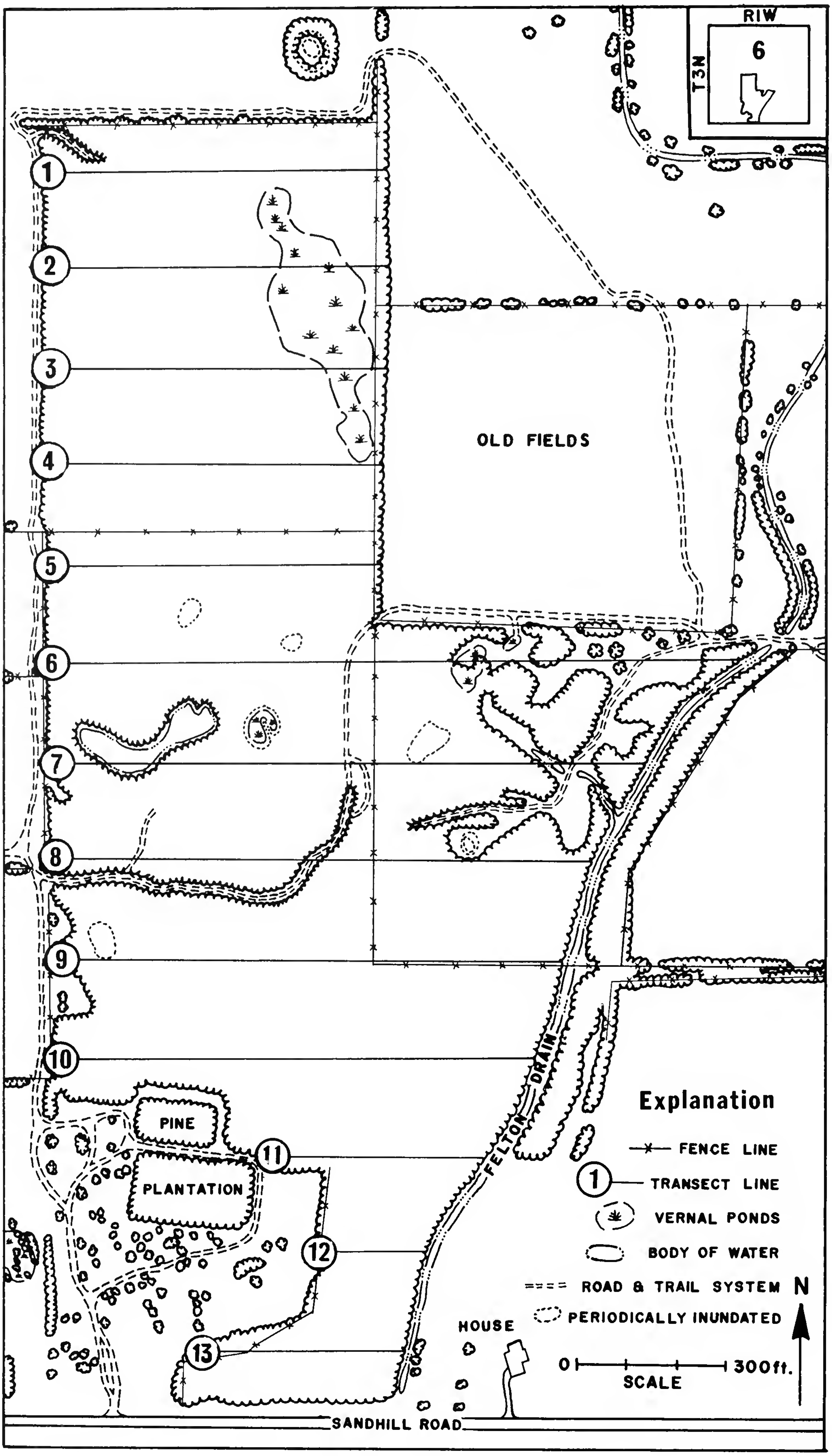
[1]This paper represents the first portion of a thesis submitted by D. M. (Valasek) Frye to the Department of Botany and Plant Pathology, Michigan State University, in partial fulfillment of the requirements for the degree of Master of Science; a checklist of vascular plants and a phenology study will follow.


R1W
T3N
6
OLD FIELDS
FELTON DRAIN
PINE
PLANTATION
HOUSE
SANDHILL ROAD
1
2
3
4
5
6
7
8
9
10
11
12
13
Explanation
FENCE LINE
TRANSECT LINE
VERNAL PONDS
BODY OF WATER
ROAD & TRAIL SYSTEM
PERIODICALLY INUNDATED
N
0
300ft.
SCALE

The land slopes (generally) toward Felton Drain and Sandhill Road. The topographic map (Fig. 3) indicates the highest point in the Woodlot to be at an elevation of 889.1 feet, which then slopes downward to an elevation of 850.0 feet at Felton Drain.

The climate of the area under investigation can be characterized as a cool temperate continental climate with approximately 31 inches of annual precipitation.

VEGETATION

In an attempt to characterize the forest structure, the occurrence and distribution of tree species were analyzed in the fall, 1971, using the point-quarter method (Cottam & Curtis, 1956). Data for individuals two inches or greater d.b.h. (diameter at breast height) were recorded at 350 randomly distributed points along thirteen regularly spaced transect lines (cf. Fig. 1). The transect lines were spaced at 200-yard intervals starting 100 yards from the northern and southern boundaries. Overlap of sample spheres was held to a minimum; however, trees were occasionally measured more than once in areas where tree density was low. The data are summarized in Table 1. Relative density, relative dominance, and relative frequency were summed to obtain the importance value.

These data indicate *Acer saccharum* is the most important tree in the Woodlot followed by a relative co-dominance of *Fraxinus americana* and *Fagus grandifolia.* Although the eight most important species are found in both upland and lowland sites, they may be more abundant in some areas than in others. The last fifteen species listed were infrequently encountered or had a very localized distribution and are therefore of limited importance to the structure of the forest.

When compared with other species of equal frequency, *Acer saccharinum* and *Quercus rubra* var. *borealis* have relatively high importance values. Both are largely represented by individuals of considerable basal area but are non-randomly distributed and are fewer in number when compared with species of equal importance. The distribution of *Acer saccharinum* is restricted to the moister soils of the vernal ponds and the Felton Drain floodplain where it replaces *Acer saccharum* as the dominant. While *Quercus rubra* var. *borealis* is not restricted to a particular area, it is more commonly found along the forest edges. *Tilia americana* appears to be below *Acer saccharinum* and *Quercus rubra* var. *borealis* in importance to the total forest structure despite its common occurrence throughout the woods. This reduced importance may be attributed to the small basal area of these apparently younger trees.

Although *Acer saccharum, Fraxinus americana,* and *Fagus grandifolia* dominate the forest structure, they do not form a homogeneous stand. Local variations in the vegetation reflect variations in soil moisture, history of the site, seed pool, etc. Based on these factors, Sandhill Woodlot can be divided

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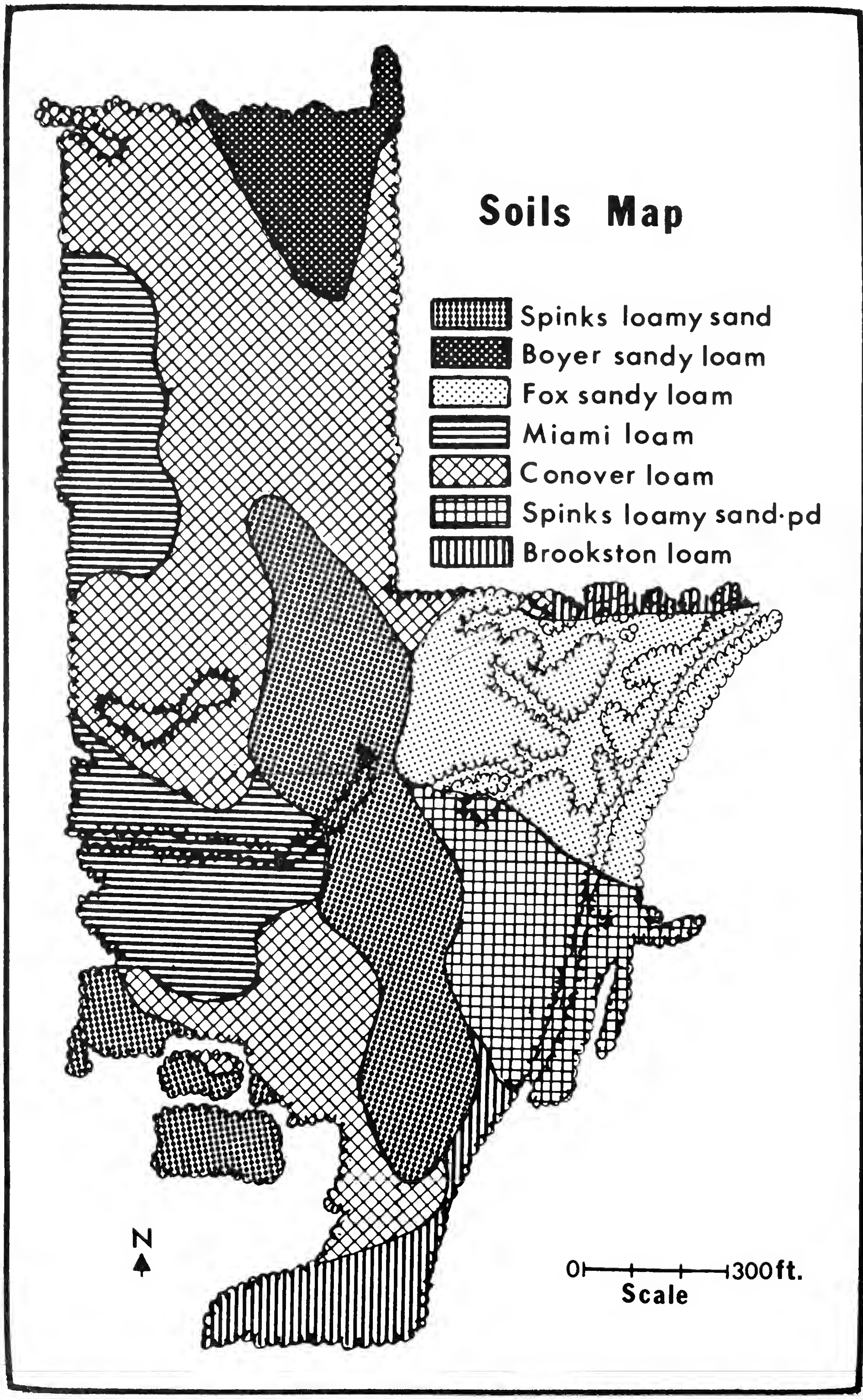
Fig. 1. Map showing the major physical and cultural features of Sandhill Woodlot. Insert in upper right corner indicates the position of the Woodlot in relation to Section 6, T3N, R1W of the Michigan Meridian, Ingham County.



Soils Map
Spinks loamy sand
Boyer sandy loam
Fox sandy loam
Miami loam
Conover loam
Spinks loamy sand·pd
Brookston loam
N
0
300 ft.
Scale

TABLE 1. Density (individuals per acre), Dominance (basal area per acre in sq. ft.), Frequency (%), and Importance Values for 26 woody species two inches or greater d.b.h. encountered at 350 point-quarters in Sandhill Woodlot.

Species	Density	Dominance	Frequency	Importance Value
Acer saccharum	76.0	38.0	45.7	73.0
Fraxinus americana	55.9	11.9	48.0	41.5
Fagus grandifolia	35.4	18.3	26.0	37.2
Prunus serotina	36.1	4.3	26.8	23.9
Ulmus americana	28.1	2.4	20.2	18.3
Ostrya virginiana	25.9	3.3	19.1	17.2
Ulmus rubra	19.3	1.6	17.0	13.9
Acer nigrum	13.7	3.4	11.4	11.1
Acer saccharinum	9.5	7.2	4.8	11.1
Quercus rubra	10.3	5.2	8.0	11.0
Tilia americana	12.9	2.4	11.1	9.9
Ulmus thomasii	9.9	0.6	9.1	6.6
Quercus macrocarpa	6.5	2.2	5.4	5.7
Populus deltoides	6.5	1.5	4.5	4.8
Populus tremuloides	9.1	0.8	4.0	4.6
Carpinus caroliniana	6.5	0.4	6.5	4.5
Rhus typhina	7.6	0.3	4.5	4.0
Quercus alba	1.9	0.7	1.7	1.8
Crataegus punctata	2.3	0.1	2.0	1.6
Acer rubrum	1.1	0.7	1.4	1.4
Malus pumila	0.8	0.2	0.8	0.7
Carya cordiformis	0.4	0.1	0.5	0.4
Cornus alternifolia	0.8	0.0	0.5	0.4
Corylus americana	0.3	0.0	0.2	0.2
Crataegus macrosperma	0.3	0.0	0.2	0.2
Viburnum prunifolium	0.3	0.0	0.2	0.2

into ten easily distinguishable habitat types. These habitats are listed by geographical location (northwest to southeast). A brief description and list of distinctive species for each habitat follow.

1. *Northern dry upland forest.* This, the driest and most sparsely populated habitat, occupies the northwestern fifth of the woods. The dominant trees are *Fagus grandifolia* and *Acer saccharum*, which are represented by large trees and very few saplings. The poorly developed understory consists primarily of grasses and large clones of *Hydrophyllum virginianum. Epifagus virginiana, Liriodendron tulipifera,* and *Panax trifolius* are unique to this habitat. The disturbance caused by the formation of a road and rock pile has introduced *Arctium minus* and *Cirsium vulgare* into the northwestern corner of the woods.

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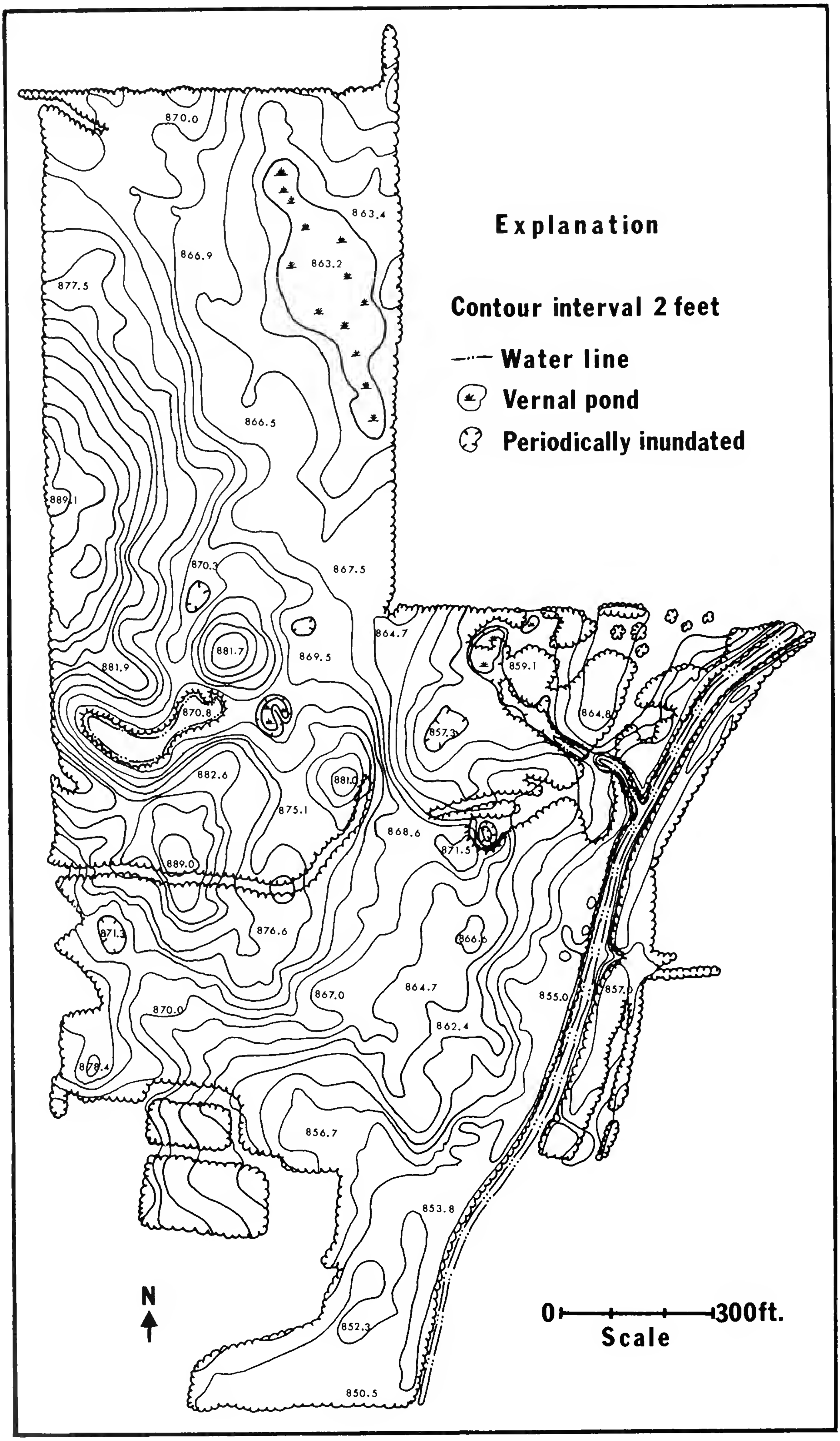
Fig. 2. Soils map adapted from a soils map of the Water Quality Research Area prepared by the Institute of Water Research, Michigan State University.


Explanation
Contour interval 2 feet
Water line
Vernal pond
Periodically inundated
N
0 300ft.
Scale
870.0
863.4
866.9
863.2
877.5
866.5
889.1
870.3
867.5
881.7
869.5
864.7
859.1
881.9
870.8
864.8
857.3
882.6
881.0
875.1
868.6
871.5
889.0
871.3
876.6
866.6
867.0
864.7
855.0
857.0
870.0
862.4
878.4
856.7
853.8
852.3
850.5

2. *Northeastern vernal ponds.* These ponds are filled only in the spring but the soil remains moist throughout the year. The numerous dead trees in this habitat are abundantly covered with mosses and fungi. The dominant tree species are *Acer saccharinum* and *Fraxinus nigra,* while *Cardamine douglassii* and *Arisaema triphyllum* are the dominant herbaceous species. *Cephalanthus occidentalis* and *Laportea canadensis* are common in several of the ponds.

3. *Central upland forest.* This habitat represents nearly two-thirds of the woodlot. *Acer saccharum, Fraxinus americana, Fagus grandifolia, Prunus serotina,* and *Ulmus* spp. dominate the woody vegetation. Saplings, largely of *Acer saccharum,* are abundant. Young trees of *Ulmus thomasii* are also quite common. In late April, the forest floor is a lush carpet of *Claytonia virginica, Isopyrum biternatum, Dicentra canadensis, D. cucullaria,* and *Erythronium americanum. Dentaria laciniata, Erigenia bulbosa, Podophyllum peltatum, Sanguinaria canadensis,* and *Carex plantaginea* are common. Flowering slightly later is an abundance of *Trillium grandiflorum.* Common in the late spring and early summer are *Geranium maculatum, Osmorhiza claytonii, Phlox divaricata, Viola canadensis, V. sororia, V. pubescens* var. *eriocarpa, Sanicula trifoliata, Hydrophyllum virginianum,* and *Geum canadense. Sarcosypha coccinea,* the scarlet cup fungus, grows abundantly in the litter.

4. *West-central cattail marsh.* The woody vegetation at the periphery of the pond, which is of sufficient size to cause a break in the canopy, contains *Acer saccharinum, Populus deltoides, Carpinus caroliniana, Corylus americana,* and *Prunus serotina.* Ferns, especially *Adiantum pedatum, Polystichum acrostichoides,* and *Athyrium asplenioides,* are abundant in this area. *Cephalanthus occidentalis, Typha latifolia, Iris virginica* var. *shrevei, Veronica scutellata, Sium suave, Scirpus cyperinus,* and several species of *Carex* grow in or along the edges of the pond. Several floating plants including *Lemna minor* and *L. trisulca* and two aquatic liverworts, *Riccia fluitans* and *Ricciocarpus natans,* grow in the pond. As the pond recedes in late summer and fall, semi-aquatic plants cover the exposed substrate.

5. *Central Zanthoxylum thicket.* An occasional tree species projects above a dense thicket of *Zanthoxylum americanum* which is characteristic of this habitat. The sparse herbaceous layer is dominated by *Phlox divaricata, Trillium grandiflorum,* and *Geranium maculatum.* Since the boundaries on three sides of this east-central habitat closely correspond to fence lines, it is probable that past land use has been instrumental in determining the vegetational composition.

6. *East-central vernal pond.* The pond, which is filled until early summer, contains *Lemna minor* and *Spirodela polyrhiza* in limited quantity. *Symplocarpus foetidus, Caltha palustris, Iris virginica* var. *shrevei, Cardamine douglassii, C. bulbosa, Lilium michiganense, Impatiens capensis, Onoclea sensibilis, Laportea canadensis,* and *Phalaris arundinacea* are common. Although the woody species, dominated by *Acer saccharinum,* are sparsely

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Fig. 3. Topographic map of Sandhill Woodlot, based on a blueprint from the Institute of Water Research, Michigan State University.

distributed, they do form a closed canopy. As the water table lowers in the summer, in contrast to the cattail marsh, the east-central vernal pond's exposed substrate supports very little vegetation.

7. *Felton Drain floodplain.* The poorly drained soils and low elevation coupled with the occasional flooding of Felton Drain cause this habitat to remain moist throughout the year. The flora of this habitat reflects an ability to tolerate high moisture levels. *Fraxinus nigra, Ulmus rubra, Quercus macrocarpa, Acer saccharinum,* and *Populus deltoides* dominate the canopy while *Sambucus canadensis, Vitis riparia, Viburnum acerifolium,* and *V. trilobum* dominate the understory. Representatives of the Umbelliferae, *Sanicula trifoliata, Crytotaenia canadensis, Osmorhiza claytonii,* and *Angelica atropurpurea,* are the dominant herbaceous components. Mosses, including *Sphagnum,* and fungi, particularly *Calvatia gigantea,* are common.

8. *Southwestern young forest.* This portion of the woods represents a younger stand where forest tree species are only saplings and a few old cultivated apple trees are present. *Rhus typhina* is common and many individuals have reached considerable size. The spring ground cover is dominated by *Claytonia virginica, Erythronium americanum, Viola sororia,* and *V. canadensis.* Summer herbs are mainly grasses and composites commonly found in older abandoned fields.

9. *Southern poplar stand. Populus tremuloides* dominates the woody vegetation in the boot-shaped southern extension of the woods while *Cornus alternifolia, Viburnum acerifolium, V. trilobum,* and *V. prunifolium* make up the understory. The herbaceous vegetation is very sparse.

10. *Edges or ecotones.* The edges of the woods are ecotones between the forest and adjacent old fields and therefore contain species common to both communities. Most of the intergrading old field successional species are members of either the Compositae or the Gramineae.

COMPARISONS WITH LOCAL WOODLOTS

Five other woodlots located on the Michigan State University Campus have been investigated in varying detail. Two of them, Baker Woodlot and Sanford Natural Area, occupy areas of comparable size to Sandhill Woodlot while Toumey, Hudson, and Bear Lake Woodlots are about half the size of Sandhill. Sanford Natural Area was last managed by the forestry department in 1960 while Baker Woodlot is still under management. Toumey Woodlot is considered to be a virgin stand and therefore was never managed. In the recent past, Hudson Woodlot was subjected to high grazing pressure including that of hogs. Bear Lake Woodlot, unmanaged, surrounds a floating mat bog on Bear Lake.

Flanders (1971) is the only study to date that makes comparisons between five of the six woodlots (Sanford Natural Area being excluded). In his study of colonial species of spring ephemerals, Flanders calculated coefficients of similarity for the five woodlots. He found the structure of Sandhill to be most similar to that of Baker although Sandhill was less diverse. Toumey Woodlot was most dissimilar with a far lower diversity. These comparisons, however, only consider a small component of the vascular plant flora.

TABLE 2. Number of vascular plant families, genera, and species found in four Central Michigan woodlots.

Woodlot	Families	Genera	Species
Baker[a]	76	176	260
Sandhill	73	175	255
Sanford[b]	87	221	345
Toumey[c]	27	30	–

[a]Totals from an incomplete checklist compiled by Warren D. Stevens.
[b]Species no longer found in Sanford subtracted from total reported.
[c]Recorded for 1960; number of species not available.

Floristic studies of Toumey, Sanford, and Baker are available. Schneider (1966) conducted a 100% inventory of Toumey Woodlot over a 20-year period. An analysis of woody vegetation and an enumeration of vascular species found in Sanford Natural Area was published by Beaman in 1970. Data from Baker Woodlot thus far have been limited to an incomplete checklist of vascular plants. Similar data were not available for Bear Lake and Hudson Woodlots. Comparing numbers of vascular plant families, genera, and species (Table 2), Toumey appears to have the least richness. This can be attributed in part to the smaller forest size and greater homogeneity of environment when compared to the other woodlots. Introduced and weedy species are almost absent in this virgin stand and thus decrease species richness. Baker, Sandhill, and Sanford have comparable size, environmental heterogeneity, and species richness. The apparent greater richness of Sanford Natural Area may be in part a reflection of the intensity of study. The Sanford list is based on 30 years of speciman collection while the Baker list reflects about two years and the Sandhill list only one. Rare species could have easily been missed in the latter two studies.

An examination of the woody species data from Sanford (Beaman, 1970) and the 1960 tree data from Toumey (Schneider, 1966) indicates that these two woodlots have greater tree density (942.1 and 566.7, respectively) than does Sandhill (377.4). This comparatively lower density may be partially attributed to sampling differences since trees between one and two inches d.b.h. were not sampled in the Sandhill study and Schneider (1966) reported 279.4 individuals per acre of his total density of 566.7 trees to be in this size class.

Although several large trees are present, the average tree size in Sandhill is smaller than that of either Sanford or Toumey. The largest tree appears to be a 36-inch *Fagus grandifolia* followed by a 30-inch and a 24-inch *Acer saccharinum.* Most trees, however, averaged a diameter of about six inches.

Acer saccharum is unquestionably the dominant tree in both Sanford and Toumey. This species is also dominant in Sandhill, but is closely followed by several other important species. *Fraxinus americana* and *Fagus grandifolia* are important to the forest structure in Sandhill as is *Prunus serotina,* seen only as an occasional tree in the other two woodlots. Although Sanford and

Toumey have greater density, Sandhill displays greater species equitability. These differences may be due to age of the woodlots, where Sandhill appears to be somewhat younger than the other two, past management, environmental conditions, and seed pool.

SUMMARY

Sandhill Woodlot, Ingham County, Michigan, supports a 44-acre forest within the Water Quality Research Area, Michigan State University Campus. A botanical inventory of Sandhill Woodlot was conducted April through October, 1971. *Acer saccharum, Fraxinum americana,* and *Fagus grandifolia* dominate the forest structure. Local variations in age, past management, and microclimate modify this structure into ten habitat types. These include a cattail marsh, vernal ponds, floodplain, *Zanthoxylum* thicket, poplar stand, dry forest, young forest, central forest, and edges.

When compared with two other Central Michigan woodlots, Sandhill appears to have greater equitability of species but less density. Species richness is equivalent to that of the other woodlots.

ACKNOWLEDGMENTS

I would like to express my appreciation to my major professor, Dr. John H. Beaman, for his guidance in the selection of this study, to my committee members, Dr. Melinda Denton, Dr. Clarence Mellinger, Dr. Stephen Stephenson, and Dr. William Tai, for their helpful suggestions, and to Mr. Thomas McMullen for his assistance in the woody vegetation analysis. Dr. Stephenson provided invaluable guidance and encouragement throughout the study.

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SHINGLE OAK (*QUERCUS IMBRICARIA*) AND ITS HYBRIDS IN MICHIGAN

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The shingle oak, *Quercus imbricaria* Michx., is the rarest and least studied of the ten oak species in Michigan. It is interesting in regard to distribution and hybridization. In this state it reaches the northernmost edge of its range and occurs in extremely localized populations. The ecology of the plant is complex. There are two habitats where it is found, one natural—wooded floodplains, the other artificial—roadsides and hedgerows. Extensive reproduction and hybridization occur especially in the man-made habitats. Hybrids involving shingle oak with three other species have been found. Of these, those that appear to be backcrossed forms are of special interest, and some of them suggest the possibility of introgression. Thus hybridization may have played a role in increasing variability and survival of *Q. imbricaria* in Michigan.

This study was carried out over a period of nearly 25 years but most of the data were collected in the years 1974 and 1975. We concerned ourselves with determining the variation, distribution, habitat preferences, and extent and nature of hydridization in the shingle oak. The field collections upon which this report is based were made mainly by the authors and all of the specimens cited in the illustrations are ours. The first set will be deposited in the University of Michigan Herbarium and duplicates will be distributed to other herbaria.

CHARACTERISTICS AND VARIATION

Quercus imbricaria belongs to the subgenus *Erythrobalanus,* the black and red oak group. Besides shingle oak, the common members of this subgenus found in Michigan include scarlet oak, *Q. coccinea*; pin oak, *Q. palustris*; red oak, *Q. rubra*; and black oak, *Q. velutina.* Another species of this group, blackjack oak, *Q. marilandica,* has been reported from the state, but we have not confirmed its presence here. Shingle oak is distinctive because of its elliptical, unlobed leaves that resemble such species of the southeastern United States as laurel-leaved oak, *Q. laurifolia,* and willow oak, *Q. phellos.*

In Michigan, the majority of shingle oaks range from 5 to 15 m in height. Trunk diameters of nearly 1 m have been observed but smaller diameters are much more frequent and most of them fall into the range of 15-50 cm. The branching is variable, and in some of the more open roadside or hedgerow habitats or in stump sprouts the plant has a deliquescent or bushy habit. The natural habitats provide the tree with a more shaded environment, and the pattern of branching tends to be more excurrent. The trunk can be distinguished from those of its near relatives by its flat, silvery-ridged bark which most resembles the bark of red oak but does not develop deep furrows.

Figure 1 shows silhouettes of the major leaf shape variations seen from plant to plant. In order to avoid effects of shading and immaturity, all the leaves were collected from peripheral, lateral branches of plants 8 m or more in height.[1] Apparent in the silhouettes are variations in both size and outline. The blade length ranges from 7 to 20 cm and the width from 1.5 to 8.0 cm. The leaves assume various shapes and the forms most commonly encountered are illustrated. They vary from elliptic (Fig. 1,a) to narrowly lanceolate (b), to ovate and obovate (c). The lanceolate leaves have more acute bases while the ovate and obovate leaves usually have somewhat more rounded or obtuse bases. In some of the leaves the margins are slightly undulate. Petiole lengths of 4-8 mm are average. Compared with all other Michigan black and red oaks, with petioles of 30-55 mm, this is very short.

The vein patterns of shingle oak leaves are strikingly different from those of other *Erythrobalanus* in Michigan. For example, in the leaves of red oak, a one-to-one relationship is commonly observed between the number of lobes and the number of major veins. Smaller, sinus veins are also found. Most

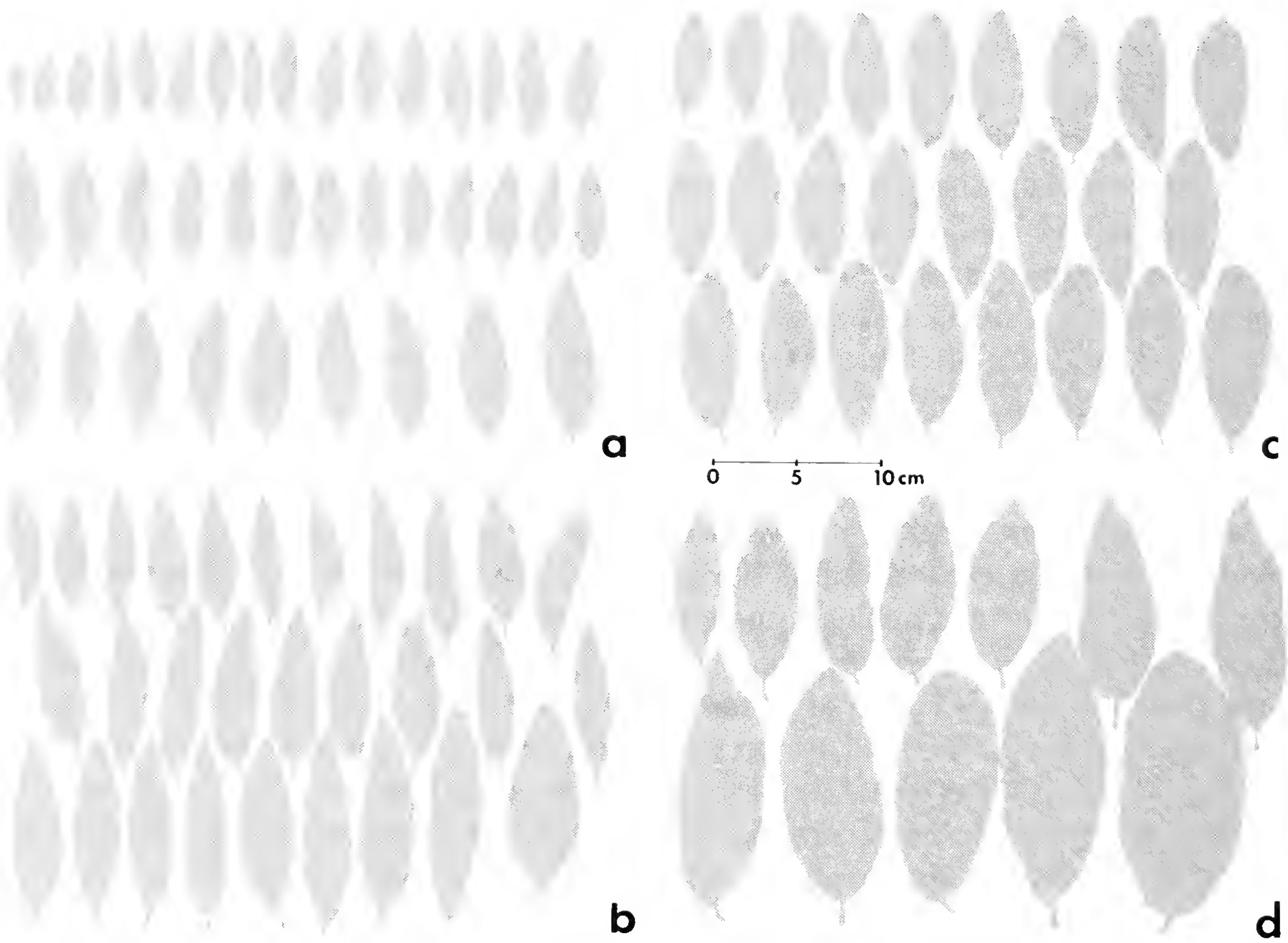

Fig. 1. Variations in leaf shape from different trees of *Quercus imbricaria.* (a) Elliptic, *74190.* (b) Lanceolate, *74182.* (c) Ovate-obovate, *74142.* (d) Large, *74214.*

[1]To determine whether our sampling technique might have introduced erroneous ideas of within-tree variation, we compared leaves from the peripheral, lateral branches in several portions of the same tree, and found that the differences were not equivalent to tree-to-tree differences.

of the major lateral or lobe veins in red oak branch form the midrib at narrowly acute angles of 40-55°. They continue in a straight to somewhat upcurved course beyond the lobe tips to form bristles.

In the entire-margined leaves of shingle oak, factors other than lobation influence the major vein pattern. There are approximately 10-25 dominant veins that extend outward in a straight course and at moderately acute angles of 50-70 degrees toward the leaf margins. About three-quarters of the distance to the margin, the dominant laterals segregate into secondary veins. The latter may join together or break themselves up into higher orders of venation that extend out to the margin. Figure 7 (d, h, & l) shows the venation of shingle oak leaves, and Figure 7 (e) shows the venation of a red oak leaf.

Differences in the thickness of veins of shingle oak and other Michigan relatives are conspicuous. As is diagrammed in the venation tracings in Figure 7 (a, e, & i) certain main lateral veins of black, red, and scarlet oak appear to be considerably stronger when compared with the shingle oak veins. This difference is obvious in living as well as pressed specimens when the finger is rubbed over the lower leaf surfaces of the species considered. The veins of shingle oak are only slightly raised, while the others have a much greater relief.

One of the most distinctive shingle oak characteristics is the winter foliage condition. Shingle oak retains a crown of dry, dechlorophyllized leaves well into the winter and even into early spring. Table 1 summarizes data taken in mid-November and compares them with the winter foliage conditions of black, red, and scarlet oaks, as well as hybrids. The majority of shingle oaks were found to keep most of their leaves. The winter foliage can be recognized by its unusual color; by mid-November the leaves have developed a tan or potato-brown color, unlike its relatives which have darker, more reddish-brown colors.

The acorns of shingle oak mature during September and October of their second year. As with the other oaks, the tree must obtain a critical size before reaching reproductive maturity. We have collected fruits from plants as short

TABLE 1. Frequency of *leaf retention* recorded for plants of *Q. imbricaria,* its hybrids, and the other hybrid parents (data collected in mid-November).

Tree	Sample size	Frequencies of leaf retention: 0-25% leaves retained	25-50% leaves retained	50% or more leaves retained
Q. imbricaria	51	0	1	50
Q. ×leana	22	17	5	0
Q. ×runcinata	10	7	3	0
Q. coccinea × imbricaria	4	2	1	1
Q. velutina	45	43	2	0
Q. rubra	26	26	0	0
Q. coccinea	11	2	6	3

as 7 m. The acorns are pictured along with the acorns of black and red oaks and their shingle oak hybrids in Figure 8. They are produced either in pairs or solitary on peduncles 5-9 mm long. The cups are turbinate, 11-15 mm in diameter and 6-8 mm long, pubescent, and reddish-brown. They enclose the nuts to about one-third of their length. The closely appressed cup scales are ovate to deltoid and have a blunt tip. The nuts are broadly ovoid to spherical, approximately 10-12 mm in width and length. The exposed surface of most of the nuts is puberulent and greenish brown.

DISTRIBUTION AND HABITAT

Shingle oak has a southern and central-midwestern range in North America. It is more common in a zone extending west from Ohio to Missouri and south to Tennessee than elsewhere. Braun (1961) reports it as "widely distributed in Ohio, but seldom abundant." Deam (1953) wrote that this species "is found throughout Indiana but in parts is a rare tree." In Illinois, Jones and Fuller (1955) called it "common throughout the state." Steyermark (1963) refers to the plant as common in most of Missouri, and in Tennessee, Gattinger (1901) described it as "especially frequent in the basin of M. Tenn." Outside of this zone, shingle oak is usually reported as rare or infrequent.

The distribution of *Q. imbricaria* in Michigan and the adjacent sections of Indiana and Ohio is shown in Figure 2.

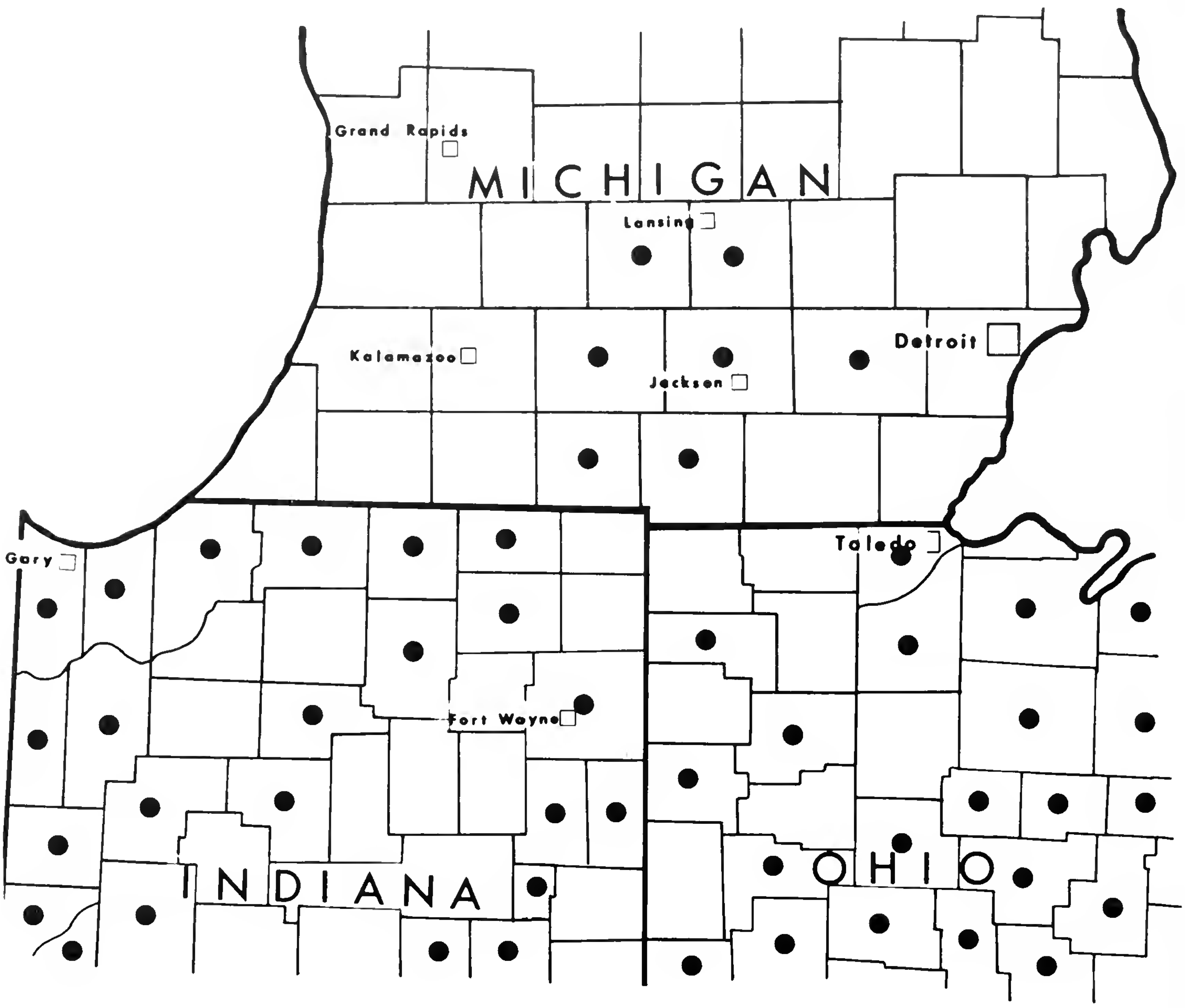

Fig. 2. County distribution of *Quercus imbricaria* in Michigan and adjacent Indiana and Ohio.

It is certainly rare in Michigan. Beal (1905) reported it from localities in Kalamazoo, St. Joseph, and Washtenaw counties; and Otis (1931) quotes the same reports. We have not been able to confirm records for shingle oak in Kalamazoo or St. Joseph counties, but we do have records from Eaton, Ingham, Hillsdale, and Jackson counties, from which it has not been previously reported.

It is perhaps understandable that shingle oak is commonly overlooked in Michigan. Most field work by botanists and foresters is conducted in spring, summer, and early autumn. It is during the warm seasons, however, that the plant is most easily mistaken for other trees with entire leaves or leaflets, as well as other oak species. We had our greatest difficulties distinguishing it from a distance from bitternut hickory, *Carya cordiformis*, pignut hickory, *C. ovalis*, black cherry, *Prunus serotina*, and sometimes even red and black oaks. In contrast, the shingle oak in winter condition is much more distinctive. With few exceptions, retention of the uniquely colored leaves renders the tree unmistakable from distances of 50-150 m. This well marked appearance coupled with the fact that most of the shingle oaks inhabit roadsides makes hunting the species from an automobile very rewarding. Moving at speeds of 20-30 miles per hour, we found that we could easily spot plants; over 3,000 miles, mainly on small secondary roads, were traveled in our field surveys. Figure 3 summarizes the results of our county-by-county survey. On many occasions we crossed fields and followed woodland edges up to a quarter- or half-mile from the roads, whenever *imbricaria*-like trees could be seen in the

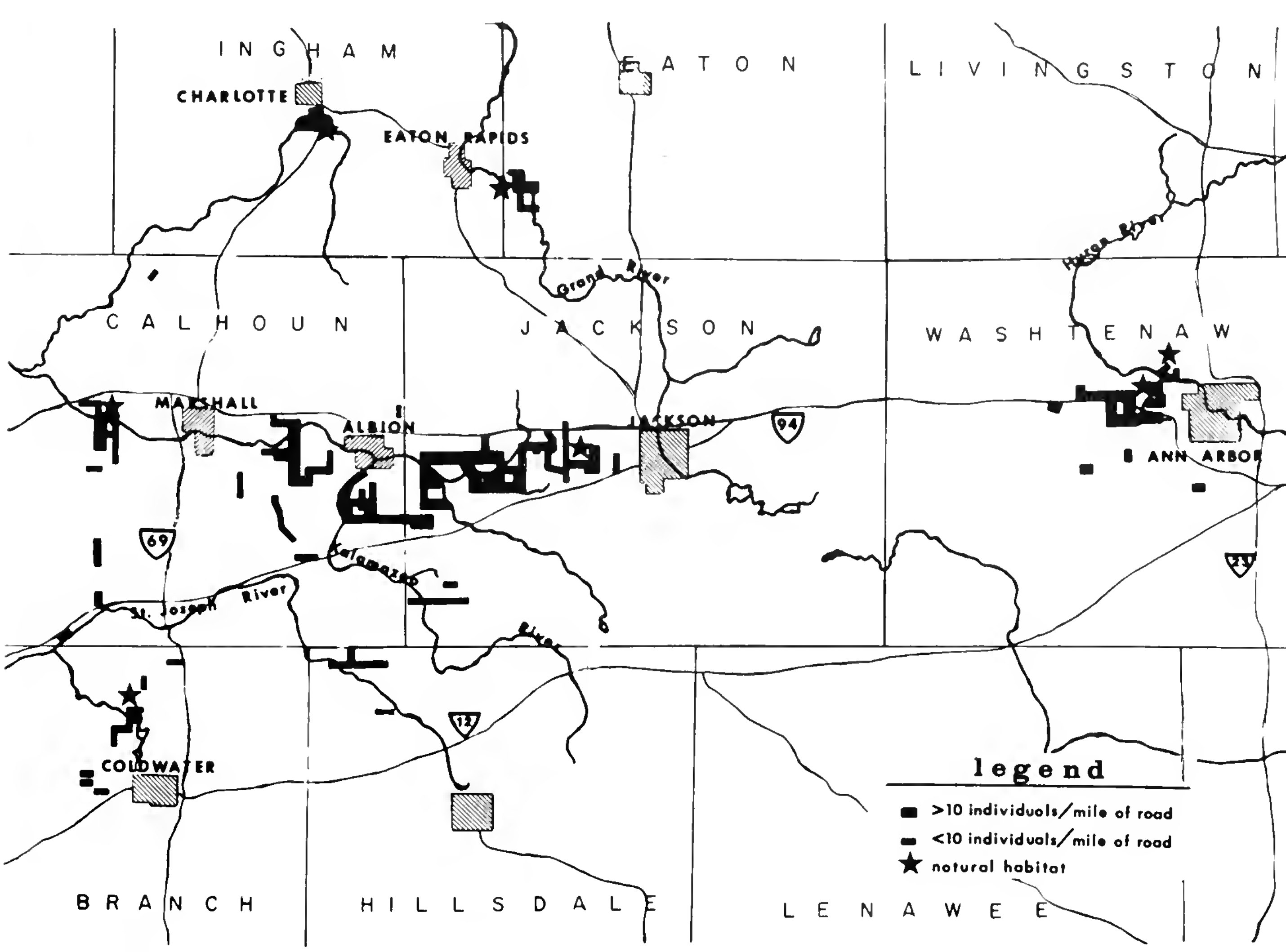

Fig. 3. Michigan distribution of *Quercus imbricaria* in relation to roads. Stars represent natural habitats.

distance or woodlands of seemingly appropriate type were encountered. The populations are highly localized, and the largest are those found between the towns of Jackson, Jackson County, and Marshall, Calhoun County. Not apparent from the map is the internal population distribution, a clumped-random one. We most commonly, in fact, encountered only a single tree or small groups of trees, these isolated from nearest neighbors.

We have seen shingle oak and its hybrids used in landscaping in the cities of Albion, Ann Arbor, and Coldwater. The tree is attractive and well suited for this purpose. Richard W. Pippen, botanist at Western Michigan University, has informed us of a planting in the city of Kalamazoo. Since we know that shingle oak is, and has been, planted in various Michigan localities, we originally entertained the possibility that the species might have been actually introduced by man and naturalized, so we concerned ourselves with testing this idea. We determined the age of one roadside tree that measured 70 cm in diameter 1 m above ground, and using a borer found that it had approximately 85 rings. Alone this would not preclude the possibility of man's introduction, since southern Michigan was settled in the early 1800's. However, some large shingle oaks of the same size as the one we measured occur as obvious stump sprouts, which represent a much older tree. In one case, the original trunk from which two sprouts of 60 cm diameter each grew was estimated as a meter in diameter at ground level because of the spacing. Taking into account a rough growth rate of 1.2 annual rings per centimeter of trunk diameter, as computed from our bored specimen, and the fact the original trunk plus its stump sprouts represent a total of at least 160 cm, an estimate of perhaps 190 years can be made, thus putting it well before southern Michigan's settlement.

We were especially interested in finding natural (i.e., non-roadside or hedgerow) habitats. A definite correlation can be made between the distribution of the shingle oak and the geology of southern Michigan. As seen in Figure 3, at almost all places where the roadside-hedgerow trees grow, a large river or creek flows nearby. This coincidence led us to suspect that the original habitat is a wooded floodplain. Our suspicions were amply supported by discovering the species growing in several wooded areas along rivers or creeks, the first along a tributary of the Grand River in the Parma area, and others along two tributaries of the Huron River, northeast of Ann Arbor, along the Coldwater River, north of Coldwater, along the Kalamazoo, west of Marshall, along Battle Creek at Charlotte, and along the Grand River southeast of Eaton Rapids. The precise areas are indicated in Figure 3 by stars. All represented originally forested sites.

Among the plant associates of shingle oak in natural sites we found red maple, *Acer rubrum,* shagbark hickory, *Carya ovata,* grey dogwood, *Cornus racemosa,* hawthorn, *Crataegus* sp., cottonwood, *Populus deltoides,* black cherry, *Prunus serotina,* red oak, and American elm, *Ulmus americana.* Common herbaceous associates include scouring-rush, *Equisetum hyemale,* sensitive fern, *Onoclea sensibilis,* and marsh fern, *Thelypteris palustris.*

As noted above and as seen in the distribution map (Fig. 3), shingle oak is far from limited to its presumed original habitat. In fact today at least, it is more common along the dry disturbed roadsides and hedgerows, these usually near rivers and creeks. That the shingle oak has become a pioneering plant in these sites is unquestioned. We have discovered several locations where the tree is actually the dominant woody plant along stretches of roadside and is reproducing up to 40 seedlings and saplings per parent.

HYBRIDIZATION

Interspecific hybridization is common and approximately seven percent of the total of pure shingle oak and its hybrids recorded in our census were hybrids. The number of hybrid individuals per population varies and seems to depend on the type of habitat in which the plants are growing. In the natural woodland sites we found no hybrids, but in roadside populations, hybrids comprised in some cases up to 25 percent of the sample. In Michigan, shingle oak reaches its northern limit and is rare so that relatively few members of its own species, as compared with other species, are producing pollen. Presumably, therefore, the pollen reaching the stigmas of shingle oak flowers consists of a high percentage from other sources, primarily other *Erythrobalanus* oaks. Also, the occurrence of shingle oak in disturbed areas probably promotes interspecific hybridization. Microsites more or less intermediate between those optimal for shingle oak establishment and for the other parents are probably formed, so that hybrids may actually be more fit than the parents to survive. Such "hybridized habitats" were first invoked by Anderson (1949) to explain hybridization and introgression in disturbed areas.

Actually the recorded abundance of shingle oak hybrids in Michigan as well as other areas may result in part from their extremely distinctive appearance. For example, the leaves of a hybrid between black and shingle oak are readily perceived because the leaf morphology in the parents is so widely different and consequently the offspring is so unusual. It is much easier to spot shingle oak hybrids than, say, red and black oak hybrids, or scarlet and red. Hybrids appear often to represent backcrosses with one of the parents in that their characteristics are closer to one than the other. Some indeed are so close to one parent as to be nearly undetectable.

Quercus ×*leana* Nutt. (*Q. imbricaria* × *velutina*).—Lea's hybrid oak is probably the most common shingle oak hybrid in the state. Approximately three-fifths of the 70 shingle oak hybrids we found were of this composition. We have collected various forms of it in Calhoun, Eaton, Jackson, and Washtenaw counties. Figure 4 gives variations. Arrangement of the silhouettes shows gradations in leaf characters from one parent to the other. The spectrum of forms is probably due to backcrossing or recombination of the hybrid character-states with the parental ones. We find an almost continuous progression from one parent to the other. Using lobe number as a primary example, black oak leaves or hybrid leaves that resemble black oak leaves (Figs. 4, b & c) have 5-7 lobes. At the opposite end of the progression hybrids with leaves similar in shape to those of shingle oak have only a suggestion of lobes, these mere teeth or bumps along the blade margins (d & e). Gradual blending of characters also involves overall leaf shape, including the leaf base. The ovate leaves with somewhat truncate bases of black oak give way in the hybrids to more and more elliptic leaves with acute bases of shingle oak. Another point concerning the leaf silhouettes involves the lobation. Lobes may resemble whole acuminate apices of shingle oak leaves (b, c, & d). Venation in these lobes is also like the shingle oak leaf apex. Much asymmetry is displayed by the hybrid. For example, the size and number of lobes may even vary from one side of the leaf to the other.

Other characters are modified through hybridization and possible back-crossing. Pubescence, for example, is nearly absent in mature black oak leaves but is dense on the lower surfaces of shingle oak leaves. In crosses, there is much variation in this respect. Retention of leaves in the winter, another feature of shingle oak, is most commonly observed in the shingle oak-like

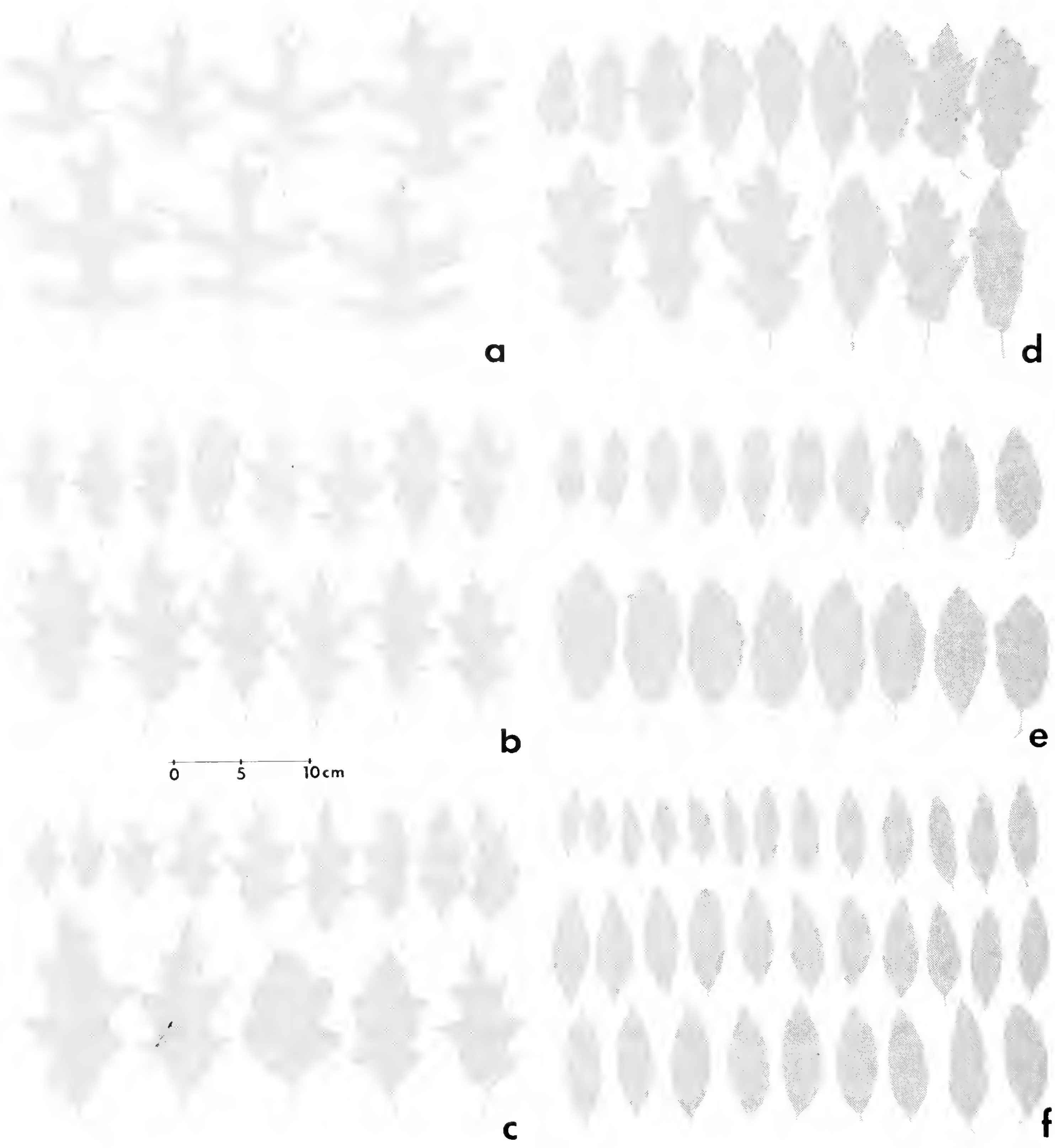

Fig. 4. Silhouettes of leaves from (a) *Q. velutina, 74184a,* (b-e) *Q.* ×*leana, 74175, 74185, 74179, 74138* respectively, (f) *Q. imbricaria, 74147.*

hybrids. The hybrids which are, in contrast, most similar to black oak tend to have dropped their leaves by mid-November.

When the vein patterns of black and shingle oak are combined, a distinctive pattern is produced. Figure 7 shows venation in two representative hybrids in the *Q.* ×*leana* complex (b & c), along with the parents (a & d). Two types of lateral veins in hybrids can be seen: Thickened lateral veins diverge from the midrib and extend to the lobe margins where they enter bristles. These are like black oak lobe veins, except for their smaller size. Narrower veins running toward the sinuses do not reach the margin, and these are like black oak sinus veins, except that they are thicker. The venation of the lobes of the hybrids tends to resemble that of the whole apex of the shingle oak leaf.

Figure 7(c) shows a leaf of a shape that suggests backcrossing. However, despite the greater influence of shingle oak genome, contributions of the black oak can be seen in the overall pattern. The tooth which interrupts the otherwise entire margin contains a vein like a black oak lobe vein.

Acorns of *Q.* ×*leana* are pictured in Figure 8. Their intermediacy between the parents is evidenced by characteristics involving the peduncle length, overall size, cup form, scale size and number, and form and size of the nut. The hybrid acorns have long cups with relatively large and few scales, as do the black oak acorns. They also express features of the shingle oak, such as the nearly spherical nut and long peduncle.

Quercus ×*runcinata* Engelm. (*Q. imbricaria* × *rubra*).—Most of the remaining hybrids of shingle oak in this study were with red oak. We have collected this hybrid in Branch, Calhoun, Eaton, Jackson, and Washtenaw counties. We have seen it used in landscaping, where its open-branched form and glossy leaves of unusual shape render it especially attractive and appropriate for this purpose.

Many of the foliar peculiarities observed in the *Q.* ×*leana* complex are present in *Q.* ×*runcinata* as well, and this is not surprising, of course, in light of the similarities between the lobed-leaved parents. The spectrum of leaf shapes in the hybrids from one parent to the other is seen, and so again there seems to be a significant amount of backcrossing or recombination of hybrids with parents or other hybrids. This is illustrated in Figure 5, where silhouettes a and f are from red and shingle oak respectively, and b-e from four different hybrid trees. Most strikingly revealed is the gradual change from the larger, widely elliptic leaves of red oak through the intermediate-sized, more narrowly elliptic leaves of the hybrids, to the smaller and more lanceolate leaves of shingle oak. Also apparent in the hybrids are gradual changes in leaf base shape, number of lobes, and petiole length. The widely acute leaf base of red oak takes on the more narrowly acute form of shingle oak. The lobe number declines from 7-9 in some hybrids to 5-7 in others and finally to only 1-3. Petiole length decreases gradually the closer the hybrids are to *Q. imbricaria.*

Figure 7 shows the venation of red oak (e), two representative hybrids (f & g), and shingle oak (h). The venation patterns of the hybrid leaves are so similar to those of *Q.* ×*leana* that they need no discussion here.

Acorns from *Q.* ×*runcinata* are pictured in Figure 8. The smaller cup with relatively broader scales is influenced by the red oak acorn, and the long peduncle is an influence of shingle oak, as well as the smaller-sized nut.

Quercus coccinea × *imbricaria.*—This is the rarest of the shingle oak hybrids, and practically no mention of it is made in regional floras. We were, in fact, only able to find one reference to it (Braun, 1961), and it has not been described or figured so far as we know. There are several possible explanations for its rarity. The association of scarlet oak with shingle is less frequent than with the other hybridizing trees. The habitats of shingle and scarlet are more differentiated from each other, on the average, than those of the other parents. Plants of the parentage *Q. coccinea* × *imbricaria* have been encountered in three Michigan localities in two counties, Calhoun and Wash-

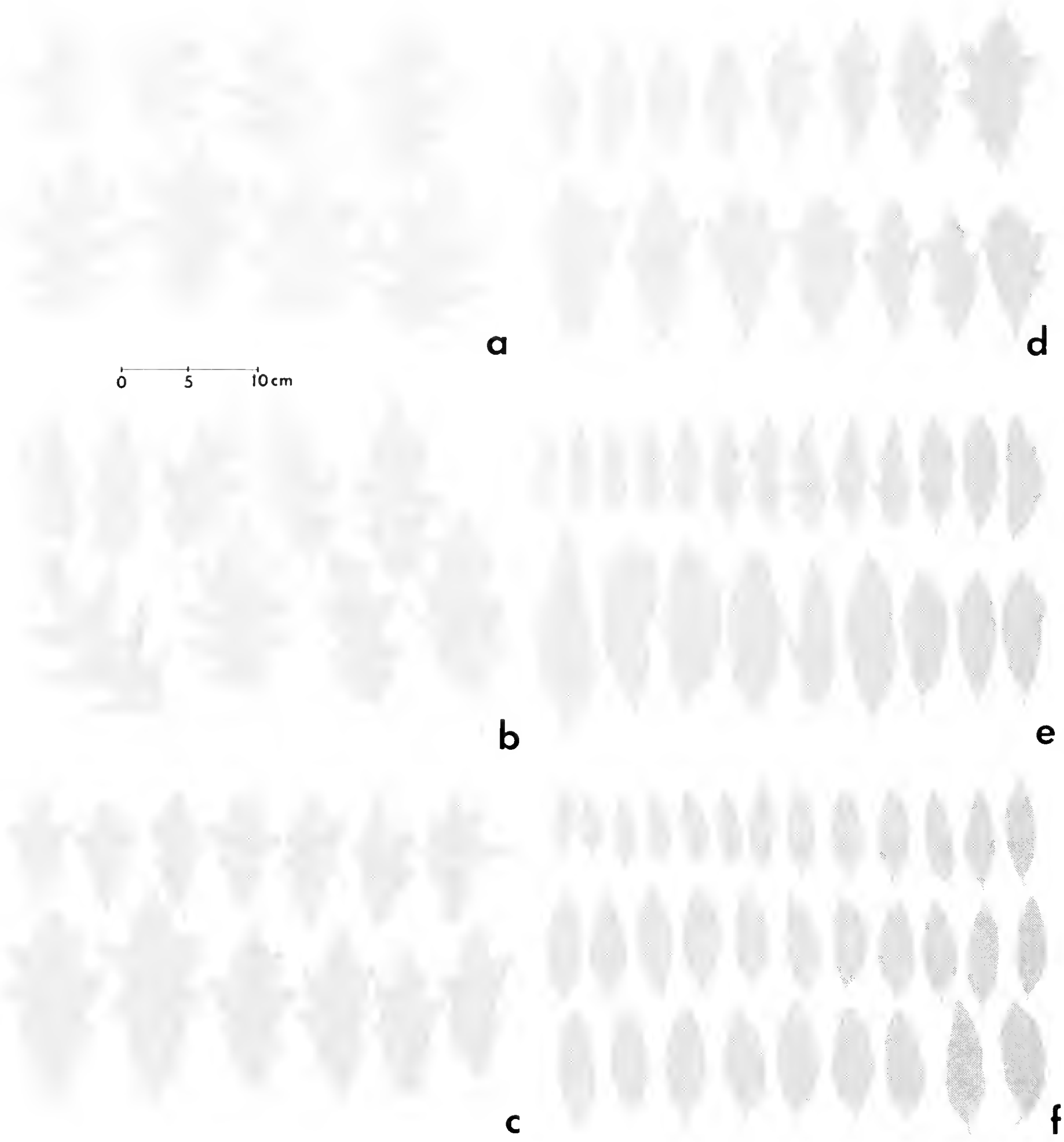

Fig. 5. Silhouettes of leaves from (a) *Q. rubra, 74180a* (b-e) *Q.* ×*runcinata, 74213, 74178, 74134, 74136,* (f) *Q. imbricaria, 74147.*

tenaw (collections nos. *74198, 74130, 75010, 75011*). One of the Washtenaw localities is especially interesting in being a disturbed area where the dry, upland habitat of scarlet oak intergrades with the more mesic, riverside habitat of shingle oak. The two parents are here the only *Erythrobalanus* species.

Figures 6 (a & f) show silhouettes of leaves from scarlet and shingle oaks, and b-e are crosses. The hybrid leaves are considerably smaller than the other shingle oak hybrids, and we have observed no apparent backcrosses or recombinations. However, the hybrids are probably all of the F_1 generation, as would be expected in view of their rarity. The ovate outline of scarlet oak is maintained in the hybrids but is narrowed by the shingle oak contribution. The hybrid leaves are somewhat like miniature leaves of *Q.* ×*leana* and *Q.* ×*runcinata.*

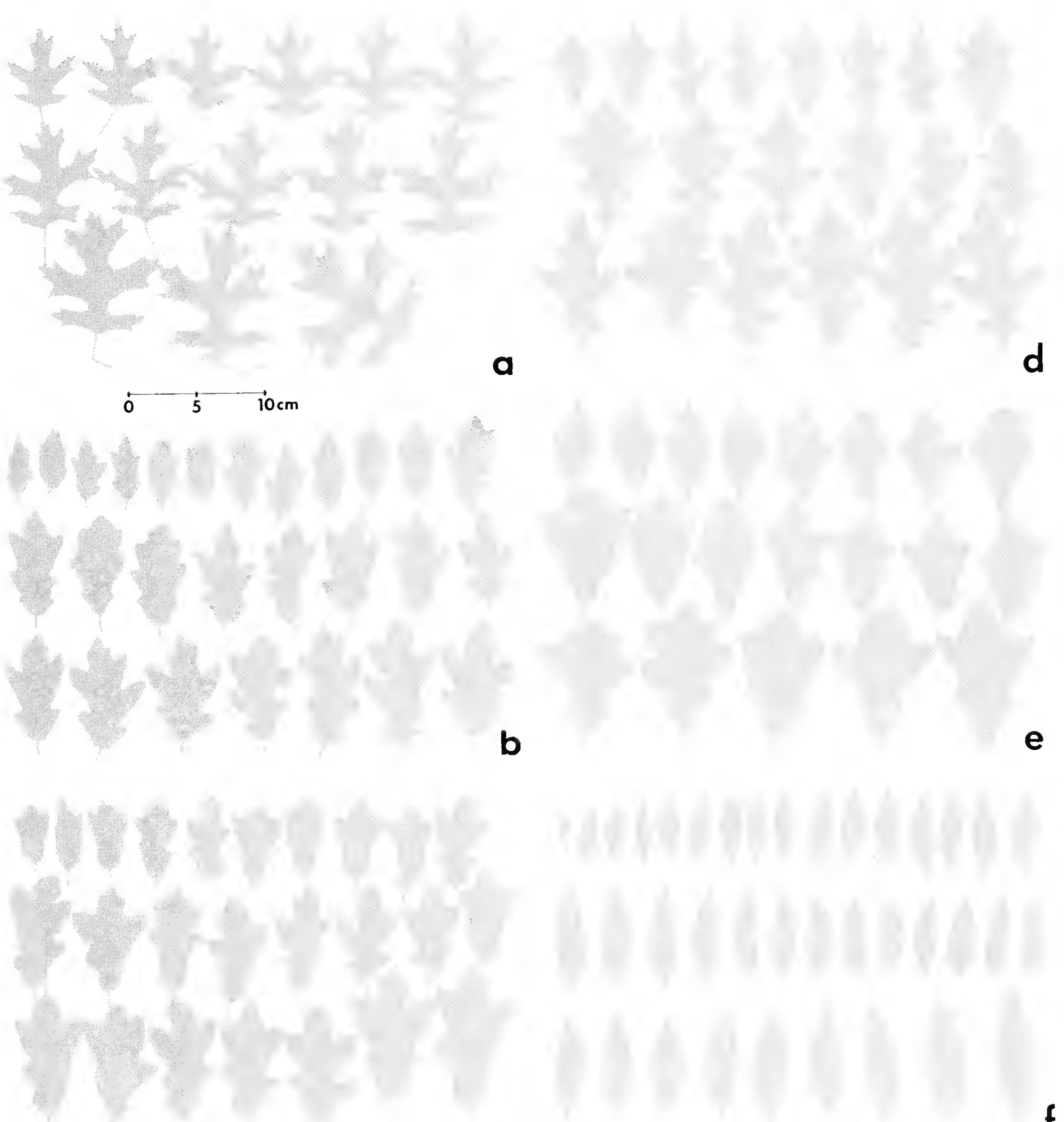

Fig. 6. Silhouettes of leaves from (a) *Q. coccinea, 74167,* (b-e), *Q. coccinea* × *imbricaria, 74198, 74130, 75010, 75011,* (f) *Q. imbricaria, 74190.*

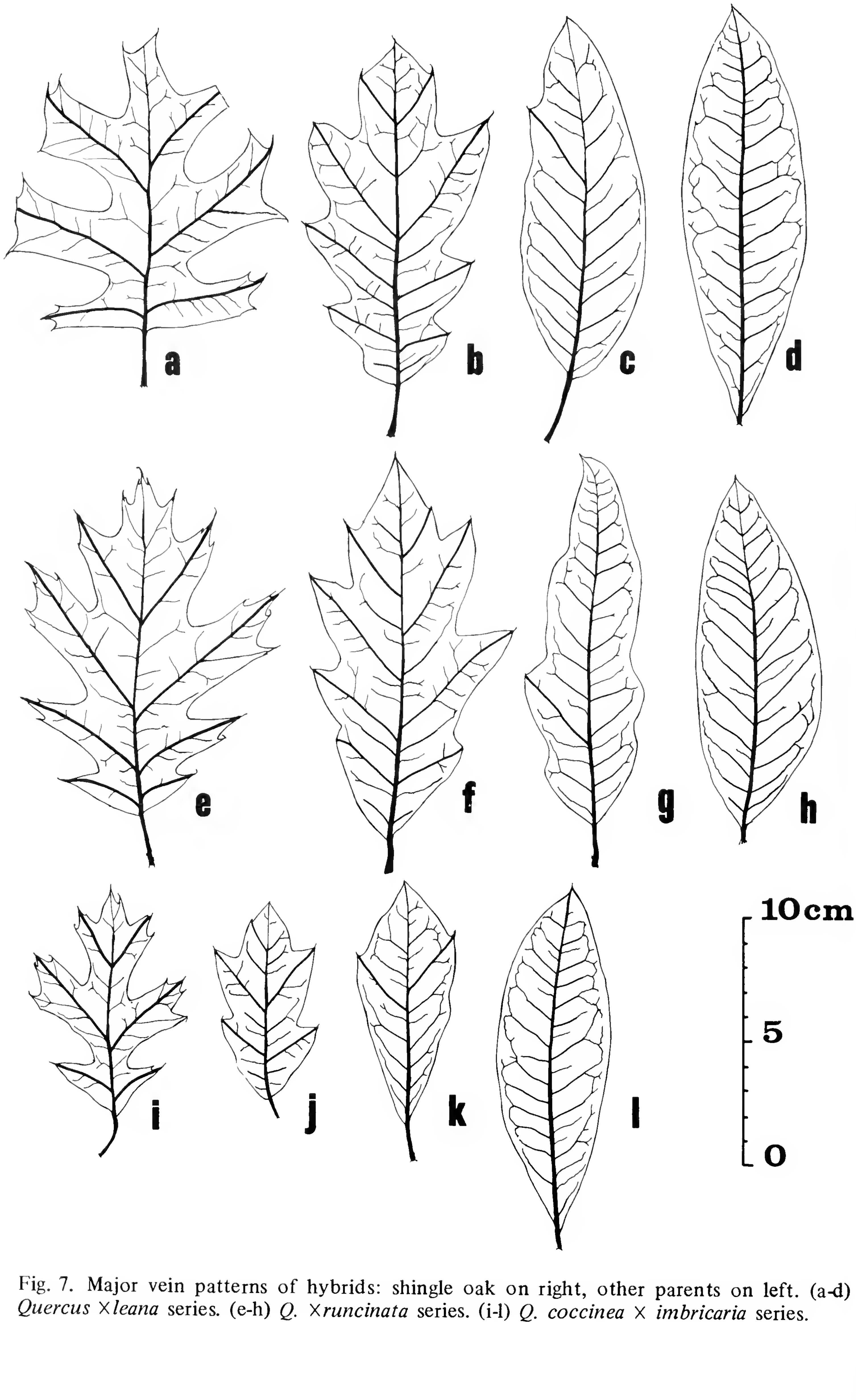

Fig. 7. Major vein patterns of hybrids: shingle oak on right, other parents on left. (a-d) *Quercus* ×*leana* series. (e-h) *Q.* ×*runcinata* series. (i-l) *Q. coccinea* × *imbricaria* series.

Both parents retain leaves until well into the winter and so do the hybrids. Thus all three taxa are conspicuous at this time of year (Table 1). As indicated, the shingle oak-scarlet oak hybrids retain more of their leaves than any other hybrids.

Figure 7 shows the venation of leaves from scarlet oak (i), two hybrids (j & k), and shingle oak (l). The same conditions prevail as in the other hybrids.

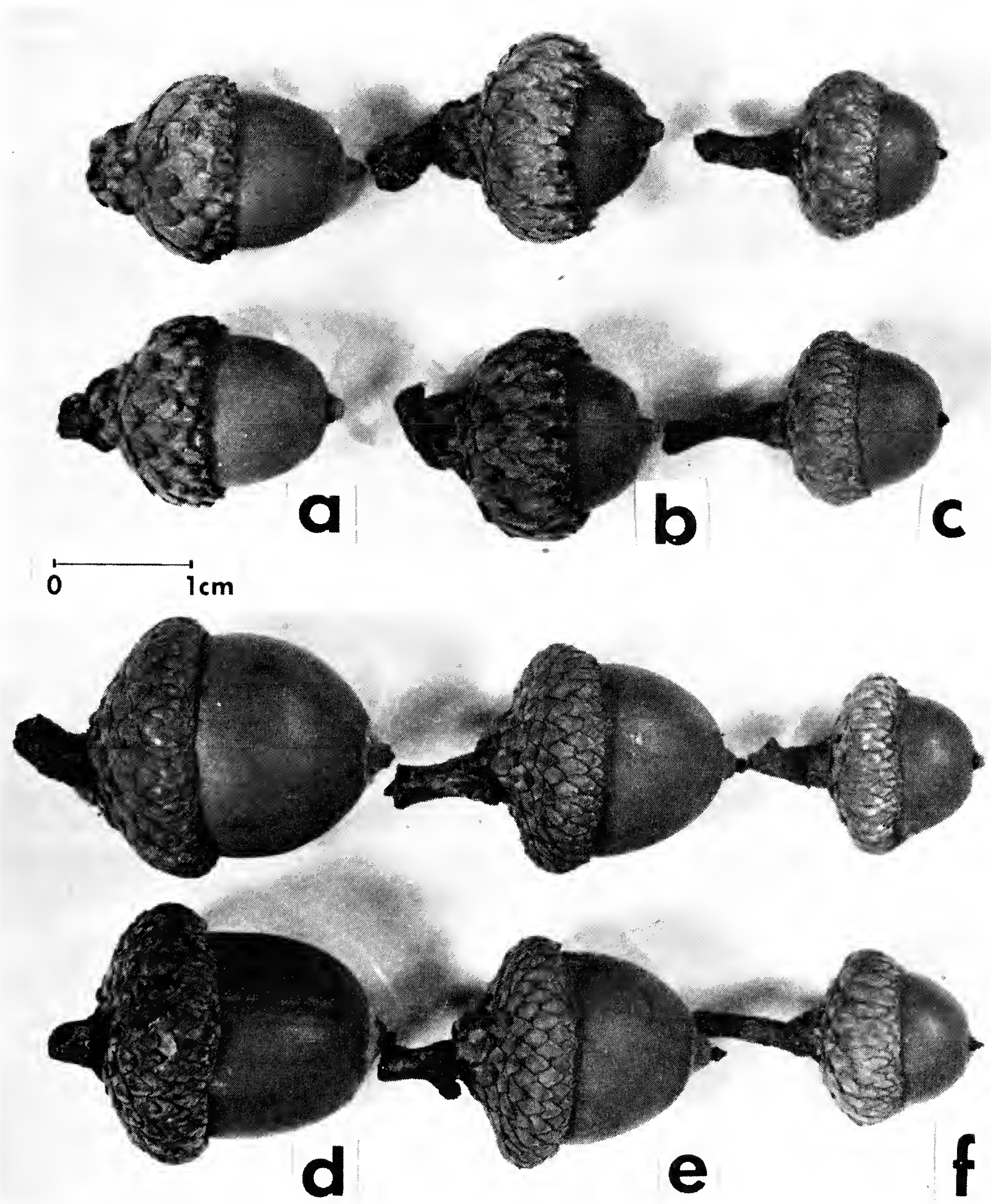

Fig. 8. Acorns. (a) *Quercus velutina.* (b) *Q.* ×*leana.* (c) *Q. imbricaria.* (d) *Q. rubra.* (e) *Q.* ×*runcinata.* (f) *Q. imbricaria.*

Unfortunately, as is so common among these plants, the hybrids we found lacked acorns so we are unable to describe them.

We do not intend to name this oak hybrid with a binomial because it is so rare. However, since it has not been previously described, we summarize its characteristics as follows:

> *Quercus coccinea* × *imbricaria.* Small tree associated with parents, the leaves obovate, 3-10 cm long, 3-12 cm wide, the petioles only half to one-third the lengths of those in *Q. coccinea,* the blades more or less irregularly lobed, the lobes 1-4 per side, each with only 1 (rarely 2-3) bristles, the blade base cuneate to truncate, the lamina relatively thin-textured but leaves tending to persist through winter. Acorns unknown.

This hybrid differs from the corresponding black and red hybrid in the following traits: Tree smaller (judging from the 4 individuals we have seen), leaves smaller, thinner-textured, more persistent in winter, and lobes relatively longer and more pointed.

DISCUSSION

One of the largest shingle oaks in the state is found in the town of Charlotte, Eaton County, at the northernmost point of the range, obviously not dwarfed by the rigors of Michigan winters. The distribution of the species is possibly limited mainly by a scarcity of the type of habitat that the tree requires. It has been reported by Deam (1953) and other authors of floras for nearby states that the plant frequently inhabits dry, upland sites, prairies, and ridgetops, as well as the lowland or floodplain habitats like those in which it is found in Michigan. Prairie and ridgetop environments of the proper type are rare in this state but man's production of roadside and hedgerow habitats serves today as a substitute.

The distribution of shingle oak and its hybrids in Michigan has been shown to be more extensive than previously reported. *Quercus imbricaria* is now known from seven counties. We have greatly increased the number of localities for hybrids. Several observations suggest that these plants are presently spreading more widely, especially in disturbed places. Extensive reproduction is going on locally in roadside areas, these located always near present or former natural habitats. Perhaps the ecological situation of shingle oak is analogous to the box elder, *Acer negundo,* which prior to man's interference with the landscape was probably mainly limited to its fairly narrow riverside habitat.

The small numbers of shingle oaks in Michigan conceivably put a strain on its potential survival. More specifically, a gene pool of restricted size lowers the potential for individual variation, which in turn decreases the capacity for adaptation. However, another source of variability may be available in the hybridization and backcrossing suggested by the spectrum of leaf shapes of crosses we have demonstrated here. Introgression is probably indicated, and it is even possible that some hybrids are so similar to one parent as to be undetectable. Woodson (1947) in studying *Asclepias* introgression reported that by the third backcross to a parent, identification of hybrids by external features was very difficult. Our estimation of a 7.3 percent shingle oak hybrid ratio to 92.7 percent shingle oak species may actually be an underestimate that does not take into consideration the true extent of backcrossing. A further suggestion of introgression derives from the leaf shape polymorphism (Fig. 1). This may be due to genetic variability introduced by the other parents. Thus the idea that introgression may be partly responsible for increasing success of shingle oaks in Michigan is an appealing hypothesis.

One of the most interesting features of the shingle oak crosses is the asymmetry in leaf shapes and venation. Wagner (1962) noticed the departure from symmetry of normally symmetrical organs or parts in hybrid ferns and flowering plants. The asymmetry involved those organs or parts that are very different in the parental species. In the oaks described here, the asymmetry involves not only different leaves on the same tree but different parts of the same leaf, as can be seen in the silhouettes (Figs. 4, 5, 6). Asymmetry in the secondary venation patterns of the hybrid leaves also occurs and this seems to be a combination of divergent patterns into one. Where asymmetry occurs it suggests a lack of compromise between parental genes; an unstable developmental situation exists in which one parent dominates some times and the other at other times.

Our investigations indicate that the hedgerow and roadside habitats are not merely "weedpatches" or "wastelots," On the contrary such habitats serve as ideal sites for shingle oak. Many other plants and animals are also found in these interesting strips of woodland which criss-cross the countryside. It is to be hoped that the ecology and floristics of such habitats will receive due attention from biologists.

ACKNOWLEDGMENTS

We thank the various students of systematic botany who contributed time and information to this investigation. We acknowledge the help especially of Joseph M. Beitel, Tomas Chavez, Robert Hammon, Karen Konarski, Janice Glimn Lacy, and Paul W. Thompson.

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Publications of Interest

From time to time we call attention, under this heading, to new publications which might be of particular interest to some of our readers but which, because of less explicit geographic or botanical orientation, do not qualify for regular review or inclusion in the listings of new literature relating to Michigan botany. All annotations are by the Editor unless ascribed to another.

PLANT CHROMOSOMES. By Áskell Löve and Doris Löve. J. Cramer, Vaduz 1975. 184 pp. DM 36.00; US $15.00 [Available in the USA from ISBS, Inc., 10300 S. W. Allen Blvd., Beaverton, Oregon 97005]. The Löves have hybridized Swanson, Sass, and Stebbins in an attempt to provide a manual of basic facts, ideas, and techniques for the non-cytologist interested in plant chromosomes. Unfortunately the field is too vast and its jargon too complicated for such an abbreviated treatment to be wholly successful. The first half, which deals with cytology and evolutionary theory, is too sketchy for the beginner and unnecessary for the more advanced student. The second half contains techniques and recipes, including many invaluable tips gleaned from years of experience. This section and the bibliography make the book worth having, but they hardly justify its price of $15.

William R. Anderson

COMMON WEEDS OF CANADA. By Gerald A. Mulligan. McClelland and Stewart Ltd., Toronto, in association with Information Canada and the Department of Agriculture, Ottawa. 1976. 140 pp. $4.95 (paper). This attractive volume is copiously illustrated with color photographs by the author, mostly of excellent quality and carefully composed so that even insignificant weeds like crab grass show up unusually well against their background. (Ten of the 117 color illustrations are taken from the old *Farm Weeds of Canada.*) One gets the impression that an honest effort was made to include those weeds actually common in Canada, and not simply the ones traditionally covered in weed books; the usually unphotogenic grasses receive fair treatment, and such often neglected but nevertheless truly common weeds (at least with us) as *Polygonum achoreum, Lepidium densiflorum,* and *Centaurea diffusa* are included. The brief bilingual text includes information on habit, origin, distribution, habitat, and flowering season. Similar species seem never to be named (e.g., two yellow Tragopogons are given without mention that there exists also a purple species).

THAT WE MAY EAT. The Yearbook of Agriculture 1975. U.S. Department of Agriculture, 1975. xxxviii + 362 pp. $7.30. The latest volume in this well known series is devoted to some of the research accomplished at the various state Agricultural Experiment Stations (the director of the Michigan station was on the Yearbook Committee). There are several local references, including the pioneering work on hybrid corn by W. J. Beal (whose name is misspelled in the index). Readable, illustrated articles on plant diseases, insect enemies, chicken, soybeans, and many other topics–even a word on breeding calmer mink in Michigan–are included. Citizens who do not care for the time and expense of ordering a copy from the Government Printing Office may request one from their Congressmen.

A BIRD OF FIRE. KIRTLAND'S WARBLER. U.S. Department of Agriculture, U.S. Forest Service Huron National Forest, in cooperation with U.S. Fish and Wildlife Service [and] Michigan Department of Natural Resources. n.d. 9 pp. This concise summary of the history and natural history of Michigan's famed bird, which nests in young jack pines in the northern Lower Peninsula, is sent by the DNR to those who contribute to "Michigan's Living Resources" fund to aid endangered species.

RESOURCE USE AND MANAGEMENT BY LARGE PRIVATE HUNTING AND FISHING CLUBS IN NORTHERN LOWER MICHIGAN. By David M. Baumgartner and Victor J. Rudolph. Michigan Agricultural Experiment Station Research Report 260. 1974. 19 pp. A general consideration of habitat management on private lands.

ANNOTATED CHROMOSOME COUNTS FOR SOME PLANTS OF THE DUNES AND PANNES ALONG THE SHORES OF THE UPPER GREAT LAKES[1]

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Several authors, notably Fernald (1925), Stebbins (1935), Guire and Voss (1963), and Voss (1972), have noted that the vegetation of the shores of the Great Lakes, and especially that of the dunes, pannes, and beach pools along the northern shores of Lakes Michigan and Huron, includes a number of species which are virtually restricted to these habitats, rarely if ever occurring elsewhere in the Great Lakes region. (The term "panne" is used here for a relatively low area, consistently moist but not inundated, between dunes or behind a dune paralleling the shore. Such moist depressions are also known as "slacks" or "wet sand-flats.") A few of these species are endemic to the Great Lakes region; others occur in populations which are disjunct, to various degrees, from populations of the same species in other parts of North America.

To date, only a few chromosome counts are available for the endemic plant species and varieties and the disjunct populations along the shores of the Great Lakes, and some of these are inadequately documented. The information that chromosomal data might provide as to the probable origins and relationships of endemic taxa, and the extent to which disjunct populations in this region have differentiated from those elsewhere, has therefore remained largely unavailable. I have, therefore, determined the chromosome numbers of some of the characteristic plants of the dunes and pannes along the shores of the Great Lakes, including several taxa which are endemic to, or disjunct in, this region, as well as some wider and more nearly continuous ranges. Chromosome counts for eight of these species are presented in this paper. Counts for other such species will be reported in later publications, in conjunction with more extensive discussions of the distribution and relationships of the respective species.

Chromosome counts were obtained from root or rhizome tips fixed immediately upon collecting in Farmer's fluid (ethanol:acetic acid, 3:1 v/v), and squashed in acetocarmine. The figures are tracings from photomicrographs. Voucher specimens are in the herbarium of the Royal Botanical Gardens (HAM).

In cases in which several chromosome counts had previously been published for a species, it was not considered necessary to provide literature citations for all previous reports. These citations can be obtained from the bibliographies compiled by Bolkhovskikh et al. (1969), which lists chromo-

[1]Contribution from the Royal Botanical Gardens, Hamilton, Ontario, No. 21, and from the University of Michigan Biological Station.

some counts published for flowering plants through 1966, and by Moore (1973), which lists documented chromosome counts for all plant groups published from 1967 through 1971.

Triglochin palustre L. Marsh Arrow-grass. 2n = 24. Michigan: Cheboygan Co.: interdunal panne at Grass Bay, ca. 6 km east of Cheboygan, Sec. 30, T38N R1E. *Pringle 1358,* 8 Aug 1972. Fig. 1.

The range of *Triglochin palustre* as given by Hultén (1968) includes most of the northern parts of North America, Europe, and Asia, as well as some of the cooler regions of the Southern Hemisphere. In North America, its distribution is nearly continuous throughout the boreal-forest zone from Labrador to Alaska. This chromosome count is apparently the first for *T. palustre* in the interior of North America. It agrees with all but one of the chromosome counts previously reported for *T. palustre,* representing this species in Africa, Europe, and Greenland. The only exception is Taylor and Mulligan's (1968) report of both n = 12 and n = 18 for *T. palustre* in the Queen Charlotte Islands, British Columbia.

Tofieldia glutinosa (Michx.) Pers. var. *glutinosa.* Glutinous False Asphodel. 2n = 30. Michigan: Cheboygan Co.: interdunal panne at Grass Bay, ca. 6 km east of Cheboygan, Sec. 30, T38N R1E. *Pringle 1516,* 30 July 1974. Fig. 2.

Classification of the North American representatives of *Tofieldia* varies greatly among recent manuals. As mapped by Hultén (1968), the range of the *T. glutinosa* complex is divided into two parts. The eastern portion extends from the Southern Appalachians north to Newfoundland, northern Québec, and eastern Manitoba; the western portion extends from California and Wyoming north to Alaska and the District of Mackenzie. Hultén treated the eastern plants as *T. glutinosa* ssp. *glutinosa,* and all those west of the disjunction as *T. glutinosa* ssp. *brevistyla* C. L. Hitchc.

Hitchcock (1969), in contrast, divided the western representatives of this complex into five varieties, with most of the plants in the northwesternmost part of its range being included, along with the eastern plants, in the nomenclaturally typical variety. Raup (1947) likewise noted that plants in Mackenzie appeared "to represent the eastern American *T. glutinosa* rather than the western *T. occidentalis.*" Yet another treatment was adopted by Ahles (1964), who reduced *T. glutinosa* of the interior of eastern North America to varietal status under *T. racemosa* (Walt.) B.S.P., typical *T. racemosa* being confined to the Atlantic and Gulf coastal plains.

The present report of 2n = 30 is the first to be published for any representative of this complex east of the disjunction in its range. The same chromosome number has previously been reported for plants which, following Hitchcock (1969), would be designated *T. glutinosa* var. *occidentalis* (S. Wats.) C. L. Hitchc., from California (Cave, 1966), and var. *glutinosa* and var. *brevistyla* (C. L. Hitchc.) C. L. Hitchc., both from the Queen Charlotte Islands, British Columbia (Taylor & Mulligan, 1968).

Zigadenus glaucus (Nutt.) Nutt. White Camas. 2n = 32. Michigan: Cheboygan Co.: dunes at Grass Bay, ca. 6 km east of Cheboygan, Sec. 30, T38N R1E. *Pringle 1614,* 4 Aug 1975. Fig. 3.

Zigadenus glaucus is present in calcareous areas in the Gulf of St. Lawrence region; the Great Lakes region, mostly in dune-panne complexes along the shores of the Great Lakes, but occasionally in fens and in wet crevices of limestone outcrops; and, rarely, in wet, calcareous habitats in the Blue Ridge Mountains of Virginia and North Carolina. *Zigadenus elegans* Pursh, a closely related species with which *Z. glaucus* has sometimes been united, is native from Missouri and Manitoba west to Nevada and Alaska.

A chromosome count of 2n = 32 reported by Miller (1930) for "*Z. chloranthus* [Richards.]" (a name formerly applied to *Z. glaucus,* but now regarded as a synonym of *Z. elegans*) was probably obtained from *Z. glaucus,* since it was distinguished from *Z. elegans.* Miller, however, cited no voucher specimens, and did not indicate the source of his plants. No other chromosome counts for *Z. glaucus* have been published, and counts for this species in other parts of its range would be desirable.

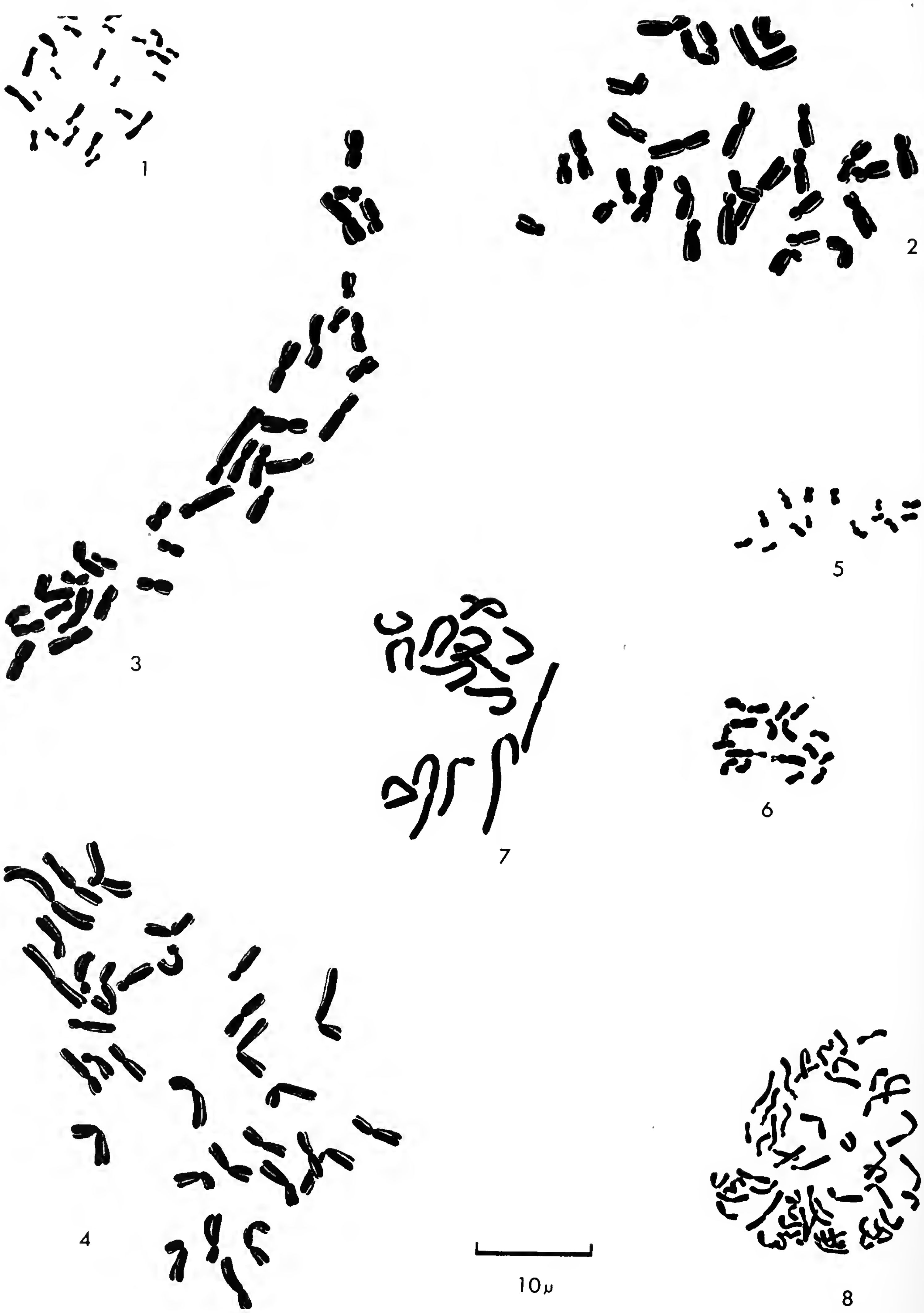
Although plants of *Z. elegans* are usually lower and bear smaller flowers than those of *Z. glaucus,* the same chromosome number of 2n = 32 has been reported for this species by several authors. The similarity of the chromosomes of *Z. elegans* and "*Z. chloranthus*" was noted by Miller (1930).

Iris lacustris Nutt. Dwarf Lake Iris. 2n = 32. Michigan: Cheboygan Co.: under pines on old dunes near the shore of Grass Bay, ca. 5.8 km east of Cheboygan, Sec. 25, T38N R1W. *Pringle 1363,* 8 Aug 1972. Fig. 4.

Iris lacustris is one of three taxa commonly recognized at the rank of species which are strictly endemic to the Great Lakes region and almost entirely confined to the shores of the Great Lakes (Guire & Voss, 1963). It is, however, obviously closely related to *I. cristata* Ait., which is native from Georgia north to northern Ohio and west to Oklahoma, and has been treated as a subspecies or variety of *I. cristata* by some authors.

Until recently, only one chromosome count had been reported for *I. lacustris,* that of 2n = 42, by Simonet in 1934. This count differed from that of 2n = 32 reported for *I. cristata,* and was considered to strengthen the case for specific status for *I. lacustris* (Simonet, 1934; Foster, 1937). In 1966, however, Kawano (in Mason & Iltis, 1966) reported the somatic chromosome number of 32 for *I. lacustris* from Bailey's Harbor, Door County, Wisconsin, the same number as that reported for Michigan material in the present paper.

In view of this discrepancy, Iltis (in Mason & Iltis, 1966) questioned the accuracy of Simonet's report, suggesting that it might have been based on a misidentified plant of *I. verna* L., another low-growing species native to the United States, for which the chromosome number of 2n = 42 had been reported by other authors. Simonet's count was obtained from a plant cultivated in England, of which the provenance was not stated. He recognized the importance of documentation, and brought the plants he had studied in England to France for incorporation into the collections of the Arboretum Vilmorin, the herbarium of which is now at the Faculté des Sciences d'Orsay



Figs. 1-8. Somatic chromosomes (Fig. 7, late prophase; all others metaphase). Fig. 1. *Triglochin palustre.* Fig. 2. *Tofieldia glutinosa* var. *glutinosa.* Fig. 3. *Zigadenus glaucus.* Fig. 4. *Iris lacustris.* Fig. 5. *Potentilla fruticosa.* Fig. 6. *Hypericum kalmianum.* Fig. 7. *Lobelia kalmii.* Fig. 8. *Tanacetum huronense* var. *huronense.*

(VIL). I have received no response to an inquiry as to the existence of herbarium specimens documenting Simonet's research, but, from the description of this herbarium given in Holmgren and Keuken (1974), it appears unlikely that specimens representing the horticultural collections were prepared. In view of the possibility that Simonet's *Iris* had been misidentified, the report of 2n = 42 for *I. lacustris* must be considered questionable. This report has not been substantiated by subsequent counts, whereas adequately documented reports of 2n = 32 now represent *I. lacustris* in two parts of its limited range.

Potentilla fruticosa L. *sensu lato.* Shrubby Cinquefoil. 2n = 14. Original source of plant, Ontario: Bruce Co.: Stokes Bay; specimen from cultivated plant at the Royal Botanical Gardens. *Pringle 1238,* 14 Aug 1970. Fig. 5.

This report of 2n = 14 is consistent with previous reports for North American representatives of *Potentilla fruticosa,* including plants from the Great Lakes region (Bowden, 1957). All plants from this continent have thus far been found to be diploids, with perfect flowers, as have those from southern Europe and much of Asia. Plants from northern Europe and adjacent portions of northern Asia, in contrast, have been found to be tetraploids, with the plants being dioecious (Elkington, 1969). *Potentilla fruticosa* is unusual in this respect, in that, in species or species groups in which dioecism is correlated with ploidy level, dioecism is more often associated with diploidy and perfect flowers with tetraploidy. The diploid plants have been segregated as subsp. *floribunda* (Pursh) Elkington, as var. *floribunda* (Pursh) Schwein., or, by advocates of the "biological species concept," as *Potentilla floribunda* Pursh or *Pentaphylloides floribunda* (Pursh) Löve.

Although chromosome counts have been published for *P. fruticosa s. lat.* in many parts of North America, it is so variable in morphology on this continent that additional counts, representing more of the varieties and forms which some authors have recognized, would be desirable.

Hypericum kalmianum L. Kalm's St. John's-wort. 2n = 18. Michigan: Cheboygan Co.: interdunal panne at Grass Bay, ca. 6 km east of Cheboygan, Sec. 30, T38N R1E. *Pringle 1519,* 30 July 1974. Fig. 6.

Hypericum kalmianum is another species which is essentially endemic to the Great Lakes region, although its range extends into the Mississippi watershed in Wisconsin, and into the Ottawa Valley in Ontario and Québec. Most of its distribution, except for populations in Ontario and Québec, has been mapped by Guire and Voss (1963). Maps by Deam (1940) and Braun (1961) cover the southernmost parts of its range in Indiana and Ohio, respectively. As noted by McLaughlin (1931), *H. kalmianum* presents a problem in evolutionary botany and phytogeography, in that all populations of this species are well within the limits of Wisconsin glaciation. According to Adams (1962), *H. kalmianum* appears to be most closely related to *H. lobacarpum* Gattinger, of the southern United States. It is, however, well differentiated from *H. lobocarpum,* and does not appear to intergrade with it or with other related species.

New chromosome counts for *H. kalmianum* have remained desirable, because the only count previously reported for this species was obtained from a cultivated plant, of which the provenance was not given, and no voucher specimen was cited (Hoar & Haertl, 1934). The present count agrees with that published by Hoar and Haertl for *H. kalmianum,* and is, moreover, the same as those reported for additional species in sect. *Myriandra* (Spach) Endl., including *H. lobocarpum,* by other authors. The basic chromosome number in this section being 9, *H. kalmianum* may be interpreted as being a diploid species.

Lobelia kalmii L. Kalm's Lobelia. 2n = 14. Michigan: Cheboygan Co.: interdunal panne at Grass Bay, ca. 6 km east of Cheboygan, Sec. 30, T38N R1E. *Pringle 1517,* 30 July 1974. Fig. 7.

This count agrees with those previously published for *Lobelia kalmii,* which represent this species in the Great Lakes region (Bowden, 1959) and elsewhere.

Tanacetum huronense Nutt. var. *huronense.* Lake Huron Tansy. 2n = 54. Michigan: Cheboygan Co.: shore of Lake Huron at Grass Bay, Sec. 25, T38N R1W. *Pringle 1272,* 27 July 1971. Fig. 8.

This is the first chromosome count to be published for the typical variety of *Tanacetum huronense,* as delimited by Fernald (1935). The same chromosome number was previously reported by Suda and Argus (1969) for var. *floccosum* Raup, the representative of this species along the shores of Lake Athabasca in northwestern Saskatchewan and adjacent Alberta. Taylor and Mulligan (1968) also reported 2n = 54 for plants from the Queen Charlotte Islands, British Columbia. They included their plants in *T. huronense* ssp. *huronense,* but in other treatments, e.g., that of Cronquist (1955), these plants would have been segregated as *T. douglasii* DC.

As indicated above, several different taxonomic treatments have been applied to the *T. huronense* complex. All of the varieties of *T. huronense* recognized by previous authors, along with *T. douglasii,* were treated by Boivin (1972) simply as *T. huronense,* although the existence of geographic variation in this complex was acknowledged. Previously, Hultén (1968) had included *T. huronense* (but evidently not *T. douglasii*) in *Chrysanthemum bipinnatum* L., as ssp. *huronense* (Nutt.) Hultén. In view of the variability within this complex, and its disjunct distribution (see Fernald, 1935; Mickelson & Iltis, 1967; and Hultén, 1968), chromosome counts from other parts of its range would be of value in determining its probable evolutionary and phytogeographic history.

The basic chromosome number in *Tanacetum* being 9, this report of 2n = 54 for *T. huronense* var. *huronense* indicates hexaploidy.

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WILLIAM G. FIELDS (1933-1975)

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William Grady Fields was born May 9, 1933, in Cranfills Gap, Texas. He attended public school in Waco, Texas, and after three years in the U.S. Army, he attended the University of Texas. In 1959 he received his Bachelor of Arts degree there and in 1961 his Master of Arts degree in mycology. The Ph.D. was conferred upon him in 1963 by Wayne State University. From 1964 through 1966 he carried out post-doctoral research on fungal genetics at Columbia University.

In January, 1967, he was hired by the Michigan State University Department of Botany and Plant Pathology as an assistant professor of mycology. In 1972, he was appointed Assistant Chairman for Academic Affairs. He was promoted to associate professor in July, 1973.

The following memorial tribute to Dr. Fields was read by the senior author at the December 2, 1975, meeting of the Red Cedar Chapter of the Michigan Botanical Club, which he had been serving as president:

IN MEMORIAM: A TRIBUTE TO DR. WILLIAM GRADY FIELDS

In the untimely passing of Dr. Fields this past Sunday morning (November 30, 1975) in a tragic fire in his apartment, the Red Cedar Chapter of the M.B.C. has lost an able, dedicated, and highly effective president. Yet the loss to the Department of Botany and Plant Pathology and the University as a whole is undoubtedly immeasurably greater.

As a colleague, Dr. Fields made many significant contributions. He will be sorely missed as a valued member of numerous graduate committees as a person who could be relied upon for good judgement, a strong sense of fairness, a sound background in science in general, and an extensive knowledge of mycology in particular. His colleagues (as well as graduate students) in Plant Pathology will especially miss his counsel on problems pertaining to fungal pathogens since Dr. Fields gave generously of his time and energies to all who asked his assistance. Busy as he was—and few faculty in the department were as busy—he was always willing to assist a colleague in offering guest lectures on his specialty, genetics of the fungi. Not only did he excel in on-campus guest lectureships, but he was also rated very highly on his off-campus teaching in Continuing Education programs. The following brief letter, written just a few weeks ago, from one of his students at Port Huron will serve to illustrate the esteem in which he was held:

> The mycology lecture and discussion which you presented last Saturday in Port Huron was fantastic. I have never attended a seminar that was more informative and practical. Your selection of material was outstanding. I enjoyed your spontaneous and direct presentation. Thank you for a profitable session, my time was well spent.

To the best of my knowledge, no other recent member of our departmental faculty has been so enthusiastically and unanimously endorsed for a university Teacher-Scholar Award as was Dr. Fields. Undergraduates in Introductory Mycology (Bot. 402), his own graduate students, and, indeed, all the graduate students in the Department at the time, as well as many colleagues, wrote letters, signed petitions and did everything possible to support Dr. Field's candidacy. These letters, petitions and statements of excellence in teaching offer abundant testimony to the outstanding abilities of Dr. Fields as a teacher at several educational levels.

Very likely those who really knew him best were those few graduate students who were privileged to be studying under his direction. To Ms. Karen Baker, a doctoral student of Dr. Fields, I am indebted for the following tribute:

> Dr. Fields had a profound effect on the intellectual pursuits of many graduate students. His striving for and achievement of excellence in teaching set a marvelous example for those of us who plan to teach at the college level. When it came to academics, either teaching or research, or even the myriad of small problems facing a graduate student every day, Dr. Fields had the admirable quality of only giving advice when it was sought; and when that advice was given, one knew that it could be trusted.
>
> His patience, encouragement and interest in both research and teaching made graduate work intellectually stimulating as well as enjoyable for many of us. He had a vast store of theoretical and practical knowledge on a variety of subjects which he was always willing to share with an inquisitive graduate student. His active participation in graduate education will be sorely missed but certainly remembered with much esteem by those of us whose academic careers are just beginning to unfold.

Moreover, his undergraduate students likewise have written on teacher evaluation forms lavish praise for this superior teacher. I quote, in part, from one recent statement from an unidentified student:

> It's hard to improve on near-perfection. I could fill more than this page on your teaching ability.—You are truly one of the finest instructors I've had in my years in college.—Thank you for a most enjoyable term.

This comment from an undergraduate student is not an isolated example, but rather expresses the reactions of many enrolled in his classes.

The many hours outside of class which he spent as an Assistant Chairman for Academic Affairs in the department recall a deep commitment to the effective functioning of the department. Finally, as an administrator, his quiet, fair-minded approach to solving difficult problems pertaining to class schedules, teaching assignments, and dozens of record-keeping details are a contribution to the smooth operation of the department which will be long remembered and difficult to duplicate.

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William Grady Fields
(1967 photo)

SPOROPOLLENIN AND MAJOR MINERAL CONSTITUENTS OF THE SPORES, ELATERS, AND CAPSULE WALL OF *CONOCEPHALUM CONICUM*

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INTRODUCTION

The term sporopollenin has been used in a broad sense to describe a class of highly polymerized natural substances resistant to acetolysis and found primarily in walls of spores and pollen grains. Erdtman (1957) demonstrated that sporopollenin is a constituent of the spores of numerous species of liverworts. The more recent studies of Rowley and Southworth (1967), Heckman (1970), and Steinkamp (1973) have dealt with the presence, localization, and distribution patterns of the sporopollenin in spore exines. Heckman (1972) and Taylor et al. (1973; 1974) have documented evidence for sporopollenin as a constituent of the elateroderms of a diverse assemblage of liverwort species. The discovery of sporopollenin localized in the helical thickening of the elateroderm (cell-wall of the elater) led to our speculation on whether or not the thickenings of the capsule-wall also contain the organic constituent sporopollenin.

Knowledge of the distribution of inorganic elements in liverworts has been confined to studies of vegetative tissue. Shacklette (1965) noted the proclivity of liverworts to accumulate certain minerals, and his findings, coupled with recent availability of the sensitive technique of energy dispersive X-ray analysis, have piqued our curiosity about the major mineral content of sporophyte tissues, and in particular of the spores.

The purposes of this paper are to present (1) evidence for sporopollenin as an organic constituent of the spore, elater, and capsule-wall, and (2) an analysis of the major mineral content of the spores, elaters, and capsule wall, based on the thalloid liverwort *Conocephalum conicum*.

METHODS

Mature capsules of *Conocephalum conicum* were harvested from axenic cultures grown on Machlis medium (1962). Air-dried (acetolyzed and non-acetolyzed) and freeze-dried (non-acetolyzed) spores, elaters, and fragments of capsule-wall were examined with the scanning electron microscope. The

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methods used for acetolysis and scanning electron microscopy were those described in Taylor et al. (1974).

A second set of air-dried (acetolyzed and non-acetolyzed) spores, elaters, and capsule-wall fragments was mounted on carbon stubs (with Duco cement) and carbon coated by vacuum evaporation. The mineral content of these samples was measured by energy dispersive X-ray analysis, with a Kevex EDX system mounted on the (Jeolco JSM-U3) scanning electron microscope. An electron beam current of 15 keV was used, with a stimulated X-ray emission of approximately 1000 counts-sec^{-1}, accumulated for 200 seconds. Estimates of the relative mineral content are based on comparison of the Kα emission peaks of the elements.

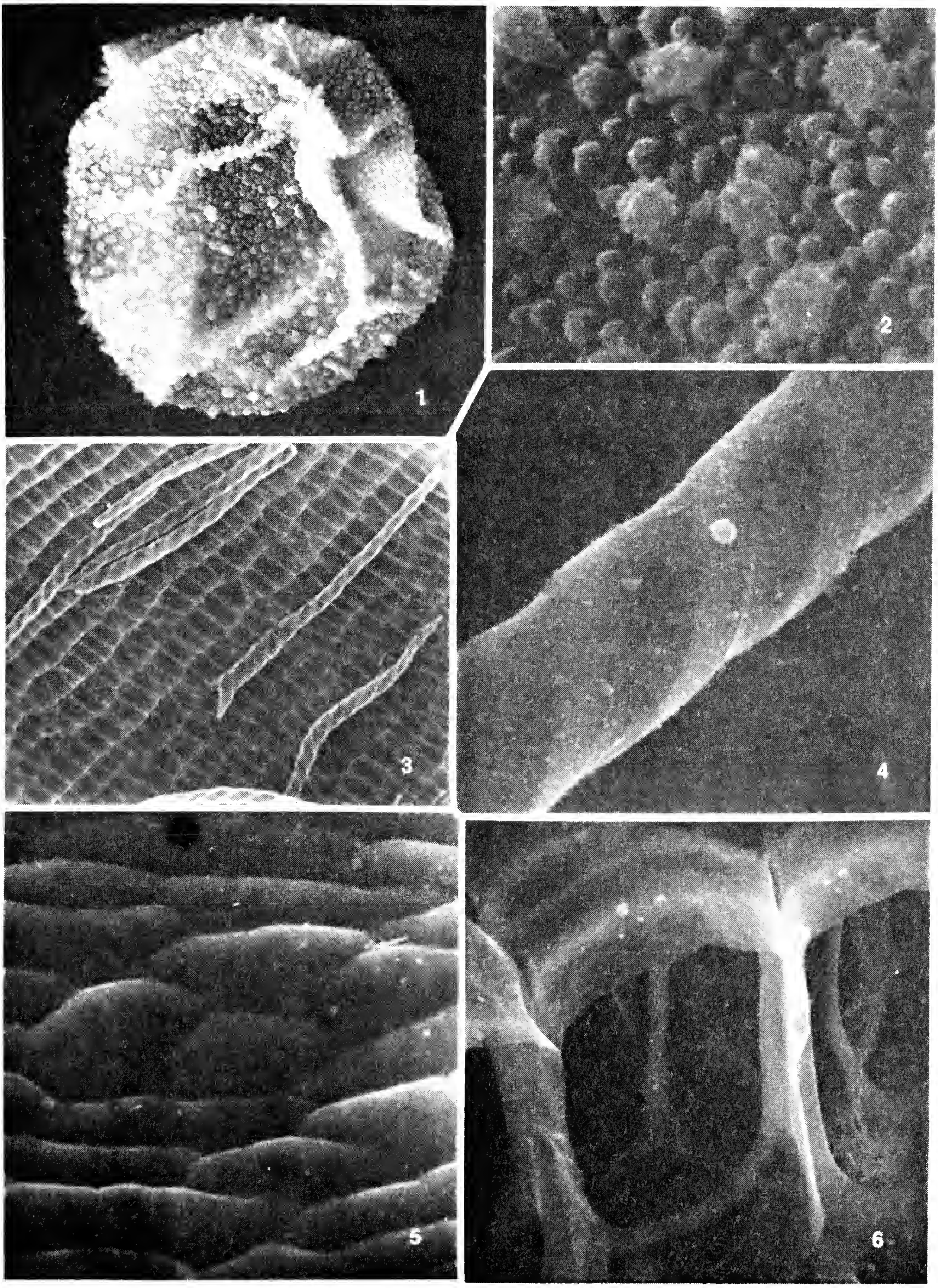
RESULTS

A scanning electron micrograph of an acetolyzed spore (Fig. 1) shows the collapsed exine and the dimorphic (granulate and verrucate) surface structures. Similar sculptural elements are visible in the micrograph of a portion of the exine of a freeze-dried, unacetolyzed spore (Fig. 2). The sculpturing of the exine is not significantly altered by acetolysis, and since sporopollenin is the substance remaining when other materials are removed by this treatment, it therefore constitutes a major structural component of the exine.

The micrograph of several elaters lying against the inner surface of the capsule wall (Fig. 3) reveals the characteristic spiral bands of thickening reinforcing a thin cellulose elateroderm. At a higher magnification, the fine structural details of the elateroderm (Fig. 4) are visible. Granular material appears randomly distributed over both the unthickened, and spirally thickened portions of the elateroderm. The spiral thickenings are resistant to acetolysis, thus testifying to the presence of sporopollenin in elaters of *Conocephalum conicum.*

The capsule-wall consists of a single layer of cells (except at the apex) with annular thickenings. In the scanning electron micrograph of the inner surface of a portion of the capsule-wall (Fig. 5) portrayed at high magnification, an artifact of electron-beam penetration renders the cell-wall thickenings visible though hardly prominent (the thickenings are much more evident in Fig. 3). Here the boundaries of the individual cells, and what appear to be polymerized globules of sporopollenin adhering to exposed cell-surfaces of the inner face of the capsule-wall, are the salient features. In a cross-section cut of the capsule-wall (Fig. 6), the hoops of thickening are clearly seen girdling the cells. These annular thickenings are resistant to acetolysis, thus implicating sporopollenin as a structural component of the cells in the capsule-wall of *Conocephalum conicum.*

When acetolyzed spores, elaters, and capsule-wall fragments were subjected to energy-dispersive X-ray analysis, all of the spectrograms showed a high peak for sulfur due to the sulfonation of sporopollenin. The spectrograms for the acetolyzed spores and elaters showed a secondary peak denoting the presence of the element silicon. Based on this evidence, the cell-wall fraction resistant to acetolysis is composed of sporopollenin, *and silicon* in spores and



Figs. 1-6. Electron micrographs of spores, elaters and portions of capsule-wall of *Conocephalum conicum*. Fig. 1. Acetolyzed spore showing exine sculpture, 600X. Fig. 2. Portion of unacetolyzed spore exine, 3,000X. Fig. 3. Elaters and surface view of inner face of portion of capsule-wall, 350X. Fig. 4. Median portion of elater, 4,000X. Fig. 5. Surface view of inner face of portion of capsule-wall with adhering globules of sporopollenin, 1,000X. Fig. 6. Cross section cut of capsule-wall showing a single layer of cells with annular thickening, 3,000X.

elaters. As reported by Maciejewska-Potapczyk et al. (1974) silicon (Si) is known to influence plant metabolism but whether its role in the spores and elaters is a physiological one or a structural one has not been determined.

In non-acetolyzed materials there are four biologically active elements—magnesium (Mg), sulfur (S), potassium (K), and calcium (Ca)—that are present in significant amounts but at varying levels in all three cell types: spores, elaters, and cells of the capsule-wall. Two additional elements, phosphorus (P), and chlorine (Cl), are present in the capsule-wall cells. Phosphorus is present at relatively high levels in capsule-wall cells and the spores, but neither phosphorus nor chlorine was detected in the elaters. Silicon is present in the spores and elaters but was not detected in cells of the capsule-wall.

Population samples from different environments may differ markedly in their content of a specific element, and there are also differences in levels of minerals in different tissues. These variables make comparisons of mineral data difficult. The histograms (Fig. 7) showing percent of total counts for each element are based on spores, elaters, and cells of capsule-wall fragments of sporophytes of an axenically cultured clone grown under controlled environmental conditions, and therefore give some degree of standardization for a comparative semi-quantitative analysis of major mineral content of all three cell-types.

Calcium, potassium, and magnesium are the principal cations (electron-deficient, or positively charged ions) detected in all three systems.

Calcium (Ca) has a high percent of the total counts in all three cell-types. In plants it has a role in cell-wall formation, and is a requirement for differentially permeable membranes (Ray, 1963). Potassium (K) is present

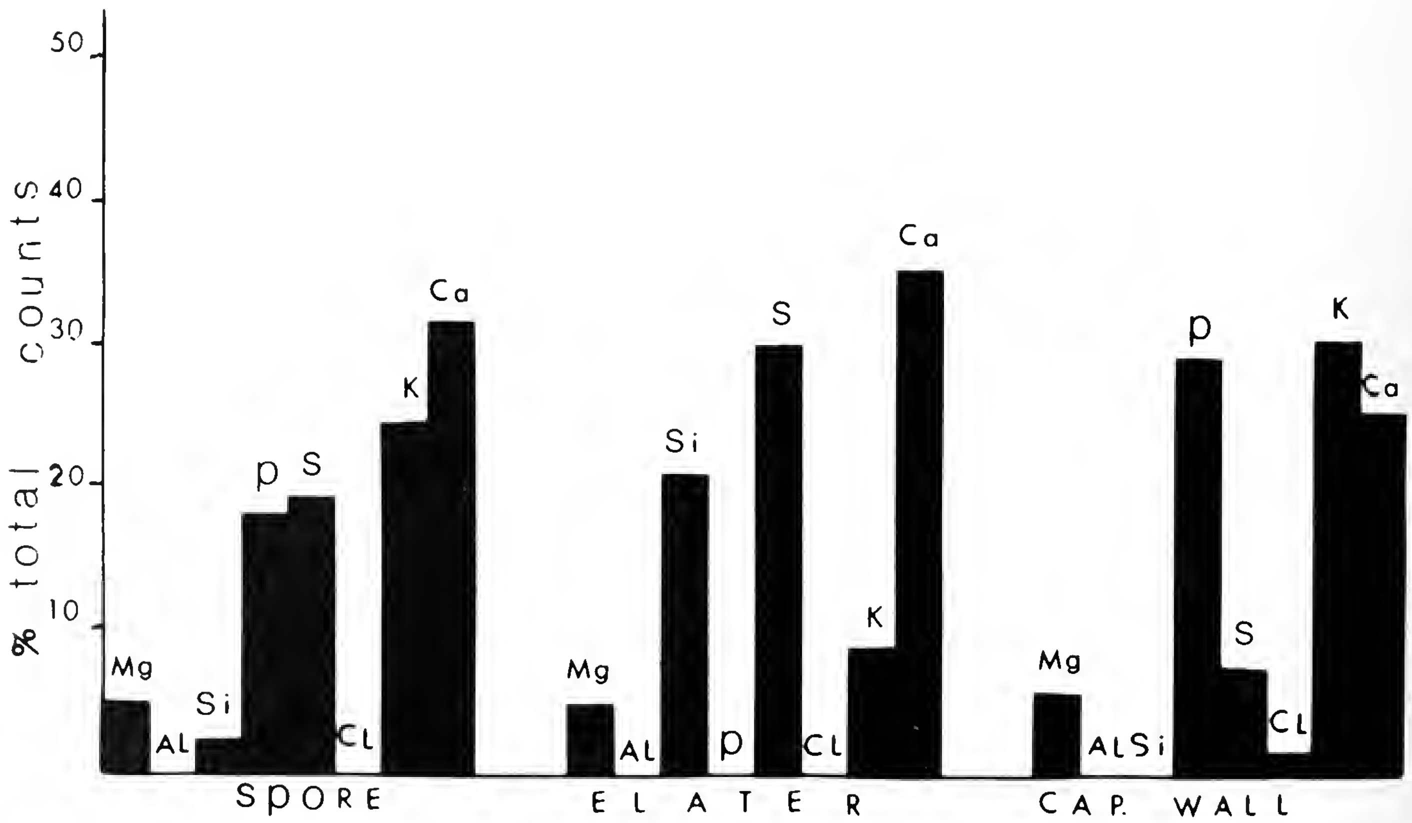


Fig. 7. Histograms comparing the relative abundance of the major elements in spores, elaters, and capsule-wall cells of *Conocephalum conicum*. The relative abundance of the elements is expressed as percent of total counts for the major elements. Mg: Magnesium, Al: Aluminum, Si: Silicon, P: Phosphorus, S: Sulfur, Cl: Chlorine, K: Potassium, and Ca: Calcium.

at relatively high levels in the spore and capsule-wall but comprises less than ten percent of total counts in the elater. High concentrations of potassium are required for protein synthesis by ribosomes, and for activation of one enzyme in glycolysis (Lehninger, 1970). The elater (a cell programed for degeneracy) loses both its nucleus and most if not all of its cytoplasm at maturity; therefore from a functional standpoint, the need for potassium decreases as the cell matures.

Magnesium (Mg) is present in all three cell-types at relatively low levels (less than 10 percent of the total counts). It is a constituent of the chlorophyll molecule, and is needed for the action of many enzymes (Ray, 1963). The low level of magnesium may reflect the absence of photosynthesis in all three-cell types at maturity and the low chlorophyll content.

The principal anions (ions with a negative charge because they have surplus electrons) are provided by sulfur, phosphorus, and chlorine (in the form of sulfate, phosphate, and chloride ions). Both sulfur and phosphorus are present in significant amounts in the spore and the capsule-wall. Sulfur plays a role in protein (-SH group essential to many enzymes), and in cofactors for oxidation of pyruvic acid; phosphorus is essential for biochemical synthesis and energy transfer (Ray, 1963). In the elaters sulfur was present in relatively high levels, but phosphorus was not detected. The elater at maturity is a dead cell with no metabolism and no membranes, and therefore the significance of the relatively high level of sulfur is difficult to explain.

The anion chlorine (Cl) was not detected in spores or elaters but accounted for a small percent of the total counts of the element in the cells of the capsule-wall. Bidwell (1974) states that a chlorine requirement has been shown to be widespread in plants. He also notes Arnon's recent discovery of an absolute requirement for chloride ions in the photosynthesis of isolated chloroplasts.

Silicon was present in significant amounts in both spores and elaters but was not detected in the capsule-wall. Kaufman et al. (1971) have enumerated a wide array of functions of silicon in plants. Our speculation is that silicon may serve in a binding capacity for the organic compounds in the spores and elaters of *Conocephalum conicum.*

DISCUSSION

Sporopollenin is a constituent of three distinct cell-types: spores, elaters, and cells of the capsule-wall in the liverwort *Conocephalum conicum.* It has long been known as the characteristic constituent of pollen and spore exines in vascular plants, but its occurrence in the lower plant groups has only recently been confirmed by Atkinson et al. (1972) in algal spores, Gooday et al. (1973; 1974) in fungal spores, and by the various authors cited in the introduction for liverwort spores and elaters. This is the first report of sporopollenin as a constituent of the capsule-wall of a liverwort.

Recent research, notably the work of Crang and May (1974), has focused attention on the need for analyses of mineral constituents of spores and pollen. Our study is a pioneer investigation of the specialized cells (including spores) and the tissue of liverwort capsules, based on *Cono-*

cephalum conicum. We found that magnesium, silicon, phosphorus, sulfur, potassium, and calcium constitute the major mineral content of the capsules with considerable differences among the levels of specific elements in the spores, elaters, and cells of the capsule-wall.

Sporopollenin and silicon are presumably structural components, resistant to chemical and physical attack, but the precise roles of all of the mineral elements have yet to be determined.

ACKNOWLEDGMENTS

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THE BRYOPHYTE FLORA OF *THUJA* SEEDBED LOGS IN A NORTHERN WHITE-CEDAR SWAMP

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Along with replenishing the forest soil and serving as a habitat for a myriad of fungi and tunnelling insects, moist, decaying logs also play an important role in forest reproduction. In comparing the germination of tree species on various substrates Fisher (1935) found that rotten wood was the most favorable germinating medium for lodgepole pine and Engelmann spruce. Curtis (1946), while studying northern white-cedar in Maine, observed that seedling root development was more extensive in decaying logs than on the forest floor, in *Sphagnum* beds, or on stumps. In a study of reproductive methods of northern white-cedar in Michigan, Nelson (1951) found that the sites of greatest seedling success were logs of slight decay in the moss stage of succession. Since the reproduction of certain tree species is indeed enhanced by the presence of seedbed logs, the availability of this habitat can influence forest succession and thus may be controlled as a method of forest management. The purpose of the present study is to characterize the type of seedbed logs important in *Thuja* reproduction and the bryophyte flora of such logs in order to determine which species are most associated with seedling establishment. A more intensive study of the microenvironment of mossy logs should follow to ascertain the actual role of these species in promoting seedling development.

METHODS

To determine the importance of mossy logs as a seedbed for *Thuja occidentalis* two sampling procedures were necessary: one for determining the frequency of logs as seedbeds and another for establishing the assortment of bryophytes characteristic of these logs. If it is indeed true that *Thuja* seedlings of a swamp habitat are predominantly found on logs (and their near equivalents, such as stumps and raised roots), then the characteristics of these seedbeds, including the bryophyte flora and the various stages of log decay, might indicate the role of mosses in seedling development. The sampling procedures used in this study were designed to reveal the type of log most favorable to seedling establishment and will help determine the characteristic bryophyte flora of these seedbed logs.

The sample area was located off a north-south gravel road at the north shore of Burt Lake, approximately 1 mile south of the University of Michigan Biological Station in a *Thuja* swamp known locally as Reeses Bog. To determine the most favorable sites for seedling development (sampling procedure 1) two 100 m transects were paced by compass line from the road into the heart of the forest. The transects were run on opposite sides of the road and were approximately perpendicular to it. Each transect consisted of four 100 m^2 quadrats (10 m × 10 m). These in turn were divided into 4 rectangular plots, each 2.5 m wide by 10 m long, to facilitate sampling and to insure that seedlings were not counted twice. The distance between quadrats was 15 m and the quadrats were established on alternate sides of the transect line. All *Thuja occidentalis* seedlings found in the quadrats were counted, and their substrates were recorded. *Picea* and *Abies* seedlings were also encountered, but they did not seem to exhibit a preference for any particular site and their substrate preferences were not studied further.

Sampling for bryophytes was done by the quarter method (procedure 2). A total of five 100 m transects were paced by compass line in a direction perpendicular to the road. The transects were run three on one side of the road, two on the other, and were spaced 50 m apart along the road. Each transect consisted of four center points at 25 m intervals along the compass line. At each center point the four nearest logs *with seedlings present* were sampled.[1] A region 1 m long on each log was sampled and the bryophyte flora, the number of seedlings present, the stage of decay of the log, and the distance from the center point to the log were all recorded. Table 1 lists all

TABLE 1. List of species encountered on seedling logs in various stages of decay.

Mosses	Mosses	Hepatics
Brachythecium acuminatum	H. pallescens	Anastrophyllum michauxii
B. curtum	Mnium affine var. rugicum	Bazzania trilobata
B. oxycladon	M. orthorrhynchum	Blepharostoma trichophyllum
B. reflexum	M. pseudopunctatum	Calypogeia meylanii
B. rutabulum	M. punctatum	Cephalozia spp.
B. salebrosum	M. punctatum var. elatum	Cephaloziella spp.
Brotherella recurvans	M. spinulosum	Conocephalum conicum
Bryhnia novae-angliae	Oncophorus wahlenbergii	Jamesoniella autumnalis
Campylium chrysophyllum	Plagiothecium cavifolium	Jungermannia lanceolata
C. hispidulum	P. laetum	Lepidozia reptans
C. stellatum	Platygyrium repens	Lophozia attenuata
Cirriphyllum piliferum	Pleurozium schreberi	L. incisa
Dicranum drummondii	Pohlia nutans	L. porphyroleuca
D. flagellare	Ptilium crista-castrensis	Pellia epiphylla
D. fuscescens	Rhynchostegium serrulatum	Plagiochila asplenioides
D. montanum	Rhytidiadelphus triquetrus	Ptilidium pulcherrimum
D. polysetum	Sphagnum capillaceum	Riccardia latifrons
D. scoparium	S. centrale	R. mutifida
D. viride	S. girgensohnii	R. pinguis
Drepanocladus uncinatus	S. magellanicum	Scapania apiculata
Eurhynchium pulchellum	S. russowii	Trichocolea tomentella
Herzogiella turfacea	S. warnstorfii	Tritomaria exsectiformis
Heterophyllium haldanianum	Tetraphis pellucida	
Hylocomium splendens	Thuidium delicatulum	
Hypnum imponens	T. recognitum	

[1]Decaying logs without seedlings were not sampled mainly due to a lack of time. A similar sampling of these logs, however, would determine whether or not seedling logs have a peculiar flora, and would afford a greater insight into the bryophyte ecology.

TABLE 2. Log classifications of McCullough (1948).

D1 – Freshly fallen trees with bark intact and needles (either green or dead) remaining on the branches which themselves are either intact or evidently broken from the trees in question.

D2 – Fallen trees with bark intact but appearing dead, with or without evidence of bark breaking up. No large branches present.

D3 – Fallen trees without bark but still solid or with bark broken up but evident in patches.

D4 – Fallen trees definite in outline with the surface grain still evident but with decay initiated along the grain.

D5 – Fallen trees definite in outline but with decay well advanced as indicated by the presence of loose fragments of wood.

D6 – Fallen trees indefinite in outline with scattered fragments of wood evident.

D7 – Fallen trees indefinite in outline, decay well advanced with few or no wood fragments present, or if present they may be easily crumbled.

D8 – Fallen trees with decay practically complete and soil formed. Outline difficult to determine.

species of bryophytes that were found growing on or over the sample logs. The stage of decay of the logs was noted according to the eight classifications outlined by McCullough in 1948 (Table 2). In sampling the bryophytes care was taken to record not only the species present, but also their approximate coverage values (expressed as a percentage of the total bryophyte cover), in order to determine those species which were the dominant components of the log bryoflora. A total of 80 logs were sampled in this manner. At each center point the species of the 4 nearest trees over 4 inches in diameter were also recorded to determine the composition of the forest in the sampling area.

RESULTS

The relative densities of the tree species in the bryophyte sample area (sampling procedure 2) were calculated by dividing the number of individuals of one species by the number of individuals of all species and multiplying by 100 (Table 3). *Thuja occidentalis* had a relative density of 65 percent, the highest of all species recorded. This value places the area sampled well within

TABLE 3. Relative densities of tree species in sample area of Reeses Bog.

Species	# trees	Rel. density (%)
Thuja occidentalis	52	65
Abies balsamea	18	22
Picea glauca	6	7.5
Acer sp.	2	2.5
Tsuga canadensis	1	1.5
Betula sp.	1	1.5
Total	80	100

the limits of what Stewart (1925) classified as cedar swamp in northern Michigan. *Abies* and *Picea* were next in order, while *Acer, Tsuga,* and *Betula* were also present.

At each point along the transects the four nearest seedbed logs were sampled and their distances from the point were recorded. By squaring the average distance and dividing this value into the number of square feet in an acre, it was estimated that there were 403 seedling-bearing logs per acre in the sample area.

Of the 1800 *Thuja* seedlings counted in the seedling survey of the present study, 73 percent were found on decaying wood (logs and stumps) while only 8 percent were found growing on the forest floor. The remaining 19 percent were found on raised humus over roots, raised humus over rocks, and in *Sphagnum* beds (Table 4). Of the seedlings counted by far the greatest number was found on logs in the middle stage of decay (here designated as D5 logs), fallen trees still with a definite outline but with some decay evidenced by loose fragments of wood in the outer 2-3 cm. Often a search for seedling roots led to a small crevice in the log, while many seedlings were found in larger chinks where small fragments of decayed material had accumulated. No seedlings were found on fallen trees with the bark still present (D1 and D2). There were many seedlings, however, on logs with decay well advanced and nearing completion (D7 and D8). Although the substrate for these seedlings was no longer clearly recognizable as log material, it nevertheless elevated the seedlings above the forest floor on a moist, penetrable platform.

Table 5 shows that of the 80 seedling logs sampled during the bryophyte survey of this study, 41 percent were in the D5 stage of decay, 26 percent were classified as D6, 24 percent D4, 4 percent D3, 2.5 percent D7, and 2.5 percent D8. Again, no seedlings were found growing on logs with the

TABLE 4. Number of seedlings found on various substrates.

Substrate	# seedlings	% of total
log D5	527	29
log D7	228	13
log D6	193	11
raised humus over roots	187	10
log D8	182	10
floor	154	9
raised humus at tree bases	113	6
stumps	105	6
log D4	83	5
Sphagnum hummock	26	1
log D3	1	–
raised humus over rock	1	–
logs D1 and D2	0	0
Total	1800	100

TABLE 5. Average bryophyte coverage and species variety on seedling logs in various stages of decay, with information concerning relative frequencies of logs sampled.

Log	# logs sampled	% total	% coverage	# species per log	Mosses per log	Hepatics per log
D1	0	0	–	–	–	–
D2	0	0	–	–	–	–
D3	3	4	67	13	6.4	6.3
D4	19	24	85	11	6.0	4.5
D5	33	41	90	11	7.0	4.3
D6	21	26	90	10	5.9	4.3
D7	2	2.5	55	9	5.0	4.0
D8	2	2.5	65	6	3.5	3.0

bark still intact (D1 and D2). Fallen trees in the D4-D6 stages of decay accounted for 91 percent of the seedling logs sampled, and the bryophyte flora is therefore of most interest on logs in this category.

Bryophytes covered an average of about 85 percent of the surface area of D4 logs, which were definite in outline, without bark and with decay loosening material along the grain (Table 5). The D5 logs had approximately 90 percent of their surfaces covered with bryophytes as did the D6 logs. The outline of the D6 logs was obscure and the surface was generally quite loose to a depth of about 5-6 cm. Logs in the D4-D6 stages of decay each supported an average of 11 different bryophyte species on their upper surfaces. Of these an average of about 4.5 were hepatics while 6.5 were mosses (Table 5).

The bryophyte species most frequently encountered on the log samples are listed in Table 6. *Lepidozia reptans,* which occurred most frequently, was found on over 80 percent of the logs sampled. This hepatic, however, is quite small and it rarely comprised more than 20 percent of the bryophyte flora of logs on which it was found. *Heterophyllium haldanianum,* on the other hand, was found on only 56 percent of the sample logs, yet often made up 50 percent or more of the flora of logs on which it grew. Hence, in order to determine which species are dominant on the logs, and possibly therefore most important in *Thuja* seedling establishment, species coverage and substrate frequency values were combined and a dominance index for each type of log in the range D4-D6 was obtained (Table 6). A dominance index usually associates density, rather than frequency, with cover. In the present study, however, the number of plants per unit area, or density, was expressed as the percentage of specific sample logs on which a particular species occurred, which is a frequency value. This was done for several reasons, not the least being the fact that it is very difficult to determine the number of plants in a moss mat or tuft.

Table 6 shows that *Heterophyllium haldanianum* was the dominant bryophyte species on logs in the D5-D6 stages of decay which supported seedlings. It was followed by *Pleurozium schreberi* on D5 logs and *Brotherella*

TABLE 6. Frequencies, coverage values, substrate frequencies, and dominance indices for the 15 most frequently occurring bryophytes on seedling logs sampled. Frequency values indicate the percentage of total sample logs on which each species occurred. Coverage numbers indicate the average percentage of total bryophyte cover for each species. Substrate frequencies give the percentage of seedling logs of a certain decay class on which each species was found. The dominance index for each species is the product of its coverage and substrate frequency values for a particular class of sample log.

		Coverage			Substrate frequency			Dominance index		
Species	Freq.	Log D4	Log D5	Log D6	Log D4	Log D5	Log D6	Log D4	Log D5	Log D6
Lepidozia reptans	81	11	10	6	68	82	95	748	820	570
Tetraphis pellucida	69	3	2	4	68	79	57	204	158	228
Cephalozia spp.	59	2	2	2	79	55	57	158	110	114
Heterophyllium haldanianum	56	25	25	26	53	64	57	1325	1600	1482
Pleurozium schreberi	54	22	19	8	63	61	48	1386	1159	384
Dicranum flagellare	53	18	8	14	63	52	43	1134	416	602
Calypogeia meylanii	51	3	5	6	37	52	76	111	260	456
Brotherella recurvans	50	9	17	23	47	49	57	423	823	1311
Jamesoniella autumnalis	35	4	2	2	47	33	33	188	66	66
Bazzania trilobata	33	12	22	22	26	27	52	312	594	1144
Blepharostoma trichophyllum	33	2	2	2	42	39	19	84	78	38
Dicranum scoparium	24	6	4	20	32	21	24	192	84	480
Hypnum imponens	23	25	36	12	32	21	24	800	756	288
Mnium affine var. rugicum	19	7	6	8	21	12	24	147	72	192
Eurhynchium pulchellum	19	60*	8	15	5	15	33	300	120	495

*Based on only one sample.

recurvans on D6 logs. On D4 logs, however, *P. schreberi* was found to be the dominant species, followed closely by *H. haldanianum.* These are all creeping, mat-forming plants with large coverage values and relatively high frequencies.

DISCUSSION

Since *Thuja occidentalis* is able to reproduce by vegetative means as well as with seedlings it was first necessary to recognize characteristics which would distinguish seedlings from other young plants. Methods of vegetative reproduction include branch layering, windthrow, and natural cuttings (Nelson, 1951). Branch layering can occur when the normally drooping lower branches come in contact with a moist medium on the forest floor (such as a *Sphagnum* hummock), develop adventitious roots, and become independent of the parent plant. Lateral branches of windthrown trees may straighten up, develop roots and become young samplings. Nelson observed reproduction by natural cuttings which sprouted roots, but did not consider this process to be a major factor in the *Thuja* life cycle. The seedlings in this study, on the other hand, were characterized by juvenile leaves, and could thus be readily distinguished from the young plants produced by vegetative means.

In the present study 73 percent of the *Thuja occidentalis* seedlings counted were supported by a decaying wood medium. The factors affecting the preference of *Thuja* seedlings for mossy logs, however, are not entirely understood. Nelson (1951) found that the seedlings showed no preference under experimental conditions for growth substrates among litter, decaying wood, floor and soil materials. He attributed the affinity of seedlings for mossy logs mainly to temperature differences. He reported that the temperature threshold for germination is approximately 14°-18° C, while the average temperature of the floor does not rise above 18° until August.

This discrepancy may be due to several factors which are consequences of the cold winters and abundant snowfall found in the region of Reeses Bog. The logs, being elevated slightly, would thaw first. The decay microorganisms in the logs would then be able to begin activity earlier than those in the humus of the floor, and thus would help raise the temperature of the logs even more. Meanwhile, the floor may be still covered with snow, ice, or cold water, and the frozen soil would not be melting under this insulating layer. These conditions are not suitable for seed germination, and furthermore are very slow in becoming more suitable due to the standing water and underlying ice. Since seed germination occurs mainly during the wet spring season when the above conditions prevail (Nelson, 1951) it was not surprising to find in the present study that decaying logs supported the greatest number of seedlings.

The standing pools of water in a cedar swamp such as Reeses Bog may not only keep floor temperatures depressed, but may also adversely affect seedling growth by decreasing the availability of air to the roots (Curtis, 1946).

Thus warmth and elevation above standing water have previously been designated as the major contributions of decaying logs in seedling establishment. Neither of the above authors, however, investigated the possible role of the bryophyte flora on seedling logs, even though seedling success was found to be greatest on logs in the "moss stage" of succession. In the present study, however, the most important seedbed logs (D4-D6) were almost completely blanketed with bryophytes. In fact, no seedlings at all were found growing on logs without some bryophyte cover. It is clear that seedling preference for mossy logs is not entirely explainable in terms of temperature and elevation, and that the bryophytic log communities may play a more active role in seedling establishment than has been previously acknowledged. A more detailed examination of the mossy log microenvironment is in order for future research, but the first step must lie in characterizing the bryophytic log flora most associated with seedling establishment. This step was the major objective of the present project.

The most common bryophytes associated with *Thuja* seedling logs appear to be pleurocarpous, mat-forming species which together nearly cover the entire upper surface of the logs. *Heterophyllium haldanianum* and *Pleurozium schreberi* were found to be the dominant species on seedling logs, while *Brotherella recurvans, Dicranum flagellare,* and *Lepidozia reptans* were also important species. On the other hand, considering what must be a close

TABLE 7. X^2 test for associated pairs among the five dominant bryophyte species on seedling logs. The hypothesis tested was that the species pair was *not associated.* A 5 percent level of significance was chosen so that with one degree of freedom, any value of X^2 less than 3.84 would be considered insignificant and the hypothesis therefore accepted.

Species pair	Occurrences together		X^2	Hypothesis
	Observed	Expected		
Heterophyllium haldanianum Pleurozium schreberi	24	25.9	.731	accepted
H. haldanianum Lepidozia reptans	39	36.6	1.98	accepted
H. haldanianum Brotherella recurvans	23	22.5	.0508	accepted
H. haldanianum Dicranum flagellare	23	23.6	.0796	accepted
P. schreberi B. recurvans	21	23.0	.818	accepted
P. schreberi D. flagellare	25	24.2	.148	accepted
B. recurvans L. reptans	33	32.5	.0821	accepted
B. recurvans D. flagellare	22	21.0	.201	accepted
L. reptans D. flagellare	36	34.1	1.16	accepted

similarity of growth conditions on seedling logs in various stages of decay, it was somewhat surprising to find that there were no associated pairs of species among the five dominants listed above. Seven 2 x 2 contingency tables were set up to test for association between species (Kershaw, 1964). The results of determinations of X^2 indicated that all of the discrepancies between expected and observed numbers of species occurring together were insignificant (Table 7). The dominant species therefore seem to be independently distributed on the seedling logs.

It appears, then, that the dominant bryophytic cover on seedling logs can best be described as a chance assortment of species which, when growing on these logs, generally form dense, carpeting networks covering 50 percent or more of their upper surfaces. These are underlain by a lacy, filamentous layer of tiny liverworts, such as *Blepharostoma trichophyllum, Jamesoniella autumnalis,* and *Cephalozia* spp. This pleurocarpous, blanketing assortment of bryophytes seems especially suited for trapping seeds shed during the moist months of early spring when the mosses are particularly pliable and thick. Otherwise the seeds might be washed or blown off the logs before they could germinate. This may explain why no seedlings were found on logs without some bryophyte cover. The loose texture of the moss mat may also be effective in retarding desiccation, which was recognized by Nelson (1951) as the greatest factor in seedling mortality.

SUMMARY

To study the bryophyte flora of *Thuja* seedbed logs in Reeses Bog, Michigan, two independent sampling procedures were necessary. The purpose of the first survey was to determine germination site preferences of *Thuja* seedlings, and a second survey was done to determine the characteristic bryophyte flora of the most suitable site for seedling germination. Of the 1800 *Thuja* seedlings counted in the first survey, over 70 percent were found on logs in various stages of decay. In the second survey the bryophyte flora of 80 logs with seedlings present was sampled. It was found that over 90 percent of these logs were in the middle stages of decay. Bryophytes were found to cover an average of nearly 90 percent of the upper surfaces of these logs. No seedlings were found on logs without some bryophyte cover. The bryophyte species most important in *Thuja* seedling establishment were found to be pleurocarpous, mat-forming plants such as *Heterophyllium haldanianum, Pleurozium schreberi,* and *Brotherella recurvans.* It is proposed that the major role of bryophytes in *Thuja* seedling establishment lies in the provision of a suitable microenvironment for seed germination.

ACKNOWLEDGMENTS

I am grateful for advice and encouragement from the following persons: Dr. William S. Benninghoff, Dr. Burton V. Barnes, Dr. Jerry A. Snider, and Dr. Howard Crum. The research was accomplished at the University of Michigan Biological Station under the direction of Dr. Crum.

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ELEOCHARIS ATROPURPUREA IN MICHIGAN

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The range of *Eleocharis atropurpurea* (Retz.) C. Presl, as in the closely related *E. caribaea* (Rottb.) Blake, is pantropical with northward extension into the United States through the Gulf of Mexico coastal plain. There the ranges of the two species diverge: *E. caribaea* ranges northeastward into South Carolina and spottily to Ontario and Michigan, while *E. atropurpurea* ranges northwestward through Iowa, Colorado, Washington, and California. Now, Michigan is found to be the northern near junction point of the divergent ranges of the two closely related species.

Within Michigan, *E. caribaea* is known only from two southeastern counties, Washtenaw and Jackson. The new *E. atropurpurea* station is in Muskegon County to the northwest. Thus, the range dichotomy of the species appears to be maintained even within the state.

The habitat of both species, on damp marly sand of pond borders, is evidently similar. At its Michigan station, *E. atropurpurea* grows on the sandy sloping shore of a pothole pond. In late summer, water still covers *Cephalanthus* bases in the bottom, and the sloping sides of the bowl are zonate with different plants, the most striking of which are *Scirpus smithii, Scirpus hallii,* and *E. atropurpurea,* in that order centrifugally. The surrounding area contains a number of other coastal plain disjunct Cyperaceae, including *Eleocharis melanocarpa, Rhynchospora macrostachya, Psilocarya scirpoides, Hemicarpha micrantha,* and *Fuirena squarrosa.*

Eleocharis atropurpurea is of lower and more rosulate habit than *E. caribaea*; culms are more filiform and achenes and scales are smaller, being 0.5 and 1 mm respectively in comparison to 0.9-1 and 1.3-1.5 mm for *E. caribaea.* Both are well illustrated in Correll and Correll (1972, fig. 196, p. 385).

Specimens of the new state record are in the herbaria of Michigan State University, University of Michigan, and Cranbrook Institute of Science. Label data: Michigan, Muskegon Co., Egelston Twp., Sect. 32, T10N, R15W. Sandy shore of small pothole pond 0.1 miles west of south end of the easternmost of Five Lakes. 23 August 1973. Churchill 73823.

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Nature education feature --

PERFECTING WILDFLOWER PHOTOGRAPHY

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INTRODUCTION

While photographing wildflowers for a book in preparation, it became apparent to us that some comments on wildflower photography might be useful to many readers of this journal.

Wildflower photographers can arrive at their interest either through nature or through photography. In any case, a person who is trained to look for details in observation probably has an advantage over one who does not. A knowledge of local flora and wildflower ecology also works in the photographer's favor. All wildflower photographers ought to consider developing as much as possible the skills of observation, and learning all that they can of details of species, plant habitats, and flowering seasons.

The style and type of photograph one intends to take depends upon the purpose it is to serve; different skills may be needed for different purposes. It is true that given enough chances, almost anyone will produce a good photograph of a wildflower. Many professional photographers feel satisfied to obtain one photograph acceptable for their purposes from several attempts. Most amateur photographers may not wish to afford such odds, however. Fortunately, careful study and composition of the plant to be photographed, plus use of the correct equipment can increase significantly the percentage of successful, usable photographs. The development of a definite philosophy of what you want your photographs to do for the viewer will add to your success. Perfection is never achieved, only worked toward.

Have you ever examined a prize-winning photograph or one so termed by experts and wondered just what qualities it possessed that caused that photograph to win over other very good photographs? In the lines that follow we have attempted to set down a few guidelines which we hope can lead to improved results for the wildflower photographer. We are deliberately omitting brand names of photographic equipment. The best way to increase quality is to learn from your mistakes. It is important to keep records of what you do such as selection of film type, shutter speeds, f stops; do not hesitate to try a photograph even if unusual conditions prevail. Eventually you will want to learn when to override camera measurements for special effects or when the situation otherwise dictates.

CAMERA

The 35-mm camera is, by far, the most widely used camera in photography today. The single lens reflex models permit focusing and composition through the same lens that takes the picture. This is especially important in critical close-up photography. Larger format cameras such as the 2¼″ x 2¼″ or 4″ x 5″ may offer certain advantages with their backs which swing or tilt, and which produce a larger sized negative, but the greatest variety of options for camera selection, number of accessories, and film types, as well as ease of operation and cost, are to be found in the 35-mm cameras.

The newest generation of 35-mm cameras is termed "automatic" and purportedly they require the user only to focus and shoot. Such cameras are superior in some situations to non-automatic models but choice will depend upon personal preference and budget. Some photographers like to maintain control over each variable during exposure of film. It is well to keep in mind that the *best* photographic equipment is not for everyone the *best value* in equipment. The photographic ability of most people never approaches the capability of their camera equipment—in other words many people over-buy for their needs. The most expensive cameras may be the best value for the professional who subjects his equipment to rugged use. Expensive cameras usually offer the feature of durability to a greater degree than do less expensive models.

When contemplating a camera purchase one would do well to discuss the different models with persons knowledgeable in photography. (These persons are not necessarily employed in camera sales.) Visits to several camera stores to examine options are most helpful, and once a tentative decision is made upon a make and model, we would suggest a few additional examinations of options elsewhere before purchasing. If you purchase correctly the first time you run less of a chance of having to purchase again in order to correct your mistake.

The serious amateur or professional may want to purchase a second camera body (without lenses). A body identical to the first offers the advantage to the user of already knowing the location of buttons, gauges, etc. on his equipment, thereby reducing the chance of "lost" controls. A second camera body further guarantees the opportunity for photography while one body is submitted for repair or cleaning. (Cleaning is recommended each 1-5 years depending upon amount and kind of usage.) Two bodies also offer the latitude of two film types such as fast and slow, or color and black-and-white.

LENSES

Which lenses should the wildflower photographer use for his work? Perhaps the most popular current choice is a "macro" lens which permits close-ups with image size of ½ to 1 times that of the subject. These lenses are usually described as having focal lengths in the range of 50 to 60 mm. However, their working distance is short (e.g., the distance from camera lens to subject may be only 10-15 cm). Certain special kinds of macro lenses are available, and some excellent brands which can be used *only* with a bellows offer much greater working distances. The 50-60 mm macro lens also can double as a "normal" lens at the expense of possible reduction of speed (smaller maximum lens aperture) and slightly less sharp image formation when focused at infinity. An additional lens often useful for wildflowers is one which falls within the 90-135 mm focal length. Such lenses are not the "macro" type since no focusing bellows is required but like the bellows-requiring macro lenses they provide longer working distances which reduce the chances of the photographer casting shadows on his subject. Image enlargement is less for these medium length telephoto lenses than for macro lenses and perspectives are different. We find telephoto lenses of this focal length to be useful for bringing in close subjects in hard-to-get-at places such as flowers just across a ditch or up on a cliff or ledge. Only in a relatively few situations might one justify the use of a wide angle (e.g. 28-35 mm) such as in photographing habitats, or a telephoto lens with a focal length over 135 mm.

All modern lenses are coated with several layers of magnesium fluoride or other similar material designated to improve the image quality. Too much coating makes the lens too "warm," i.e. emphasizes the red and yellow colors while too little coating brings out the blue colors to an excess.

A lens of good quality has two important characteristics worth noting: (1) the *glass* elements are of the highest quality and ground to great precision and (2) the lens *mount* is well-constructed from a durable metal that will withstand long use without allowing the lens to become mis-aligned, resulting in image distortion. Lens quality is about the *last* place to make a sacrifice for the sake of economy.

FILM

Most experts on photography advise us to settle on one or two films and stay with them since this permits opportunity for greater familiarity with their limitations. However, it is useful to be aware of the advantages and disadvantages of additional films for those situations where the photographer wants to emphasize certain features of the subject. For the most part one might decide, let us say, on two film types—one color film and one for black and white. An additional option might be a fast and a slow version of each of the two basic types.

There is no film made which will faithfully reproduce all colors in all situations. Research by film manufacturers has shown that by far most photographs are of people. This implies a marketability for fidelity in the skin tones which include the red, yellow, and orange portion of the visible spectrum. The greens in such cases may get short shrift. We find that no slide film produces good greens as well as true fidelity for the wide range of flower colors. We observe the flowers in the field by *reflected* light. Our transparency photographs of them are observed by *transmitted* light. Fundamental problems arise when attempting to produce a color by one mode when it was recorded in another mode. The difficulty of making accurate color prints from a color transparency is especially great.

The matter of a granular appearance (graininess) in a photograph is most annoying to some persons while others find this is not objectionable. For choice of color film one must contend not only with accurate representation of color but also with the graininess factor. Faster films usually exhibit more graininess than do slower ones and tend to produce warmer color tones.

TRIPOD

Ideally, wildflower photographs–indeed almost all photographs–should be made with the aid of a tripod. Even at speeds of 1/100 second greater sharpness (measured in lines per mm) can be achieved using a tripod over the hand-held method. There is, expectedly, a direct relationship between tripod size (and/or weight) and stability of the camera. There is no substitute for a good, sturdy tripod. There are available now horizontal arm extensions which can be attached to the end of the tripod centerpost. When so attached and with the centerpost inverted, i.e. hanging upside down, this horizontally projecting arm with the camera at its far end allows the photographer maximum movement around the subject, e.g. violets, without bumping into or working beneath the tripod legs. For very low subjects a small table-top tripod might suffice but offers far less stability than the horizontal arm arrangement.

The choice of a tripod head is important but perhaps less critical than the tripod choice itself. A ball and socket head is the lightest and simplest arrangement and offers the quickest means of orienting the camera in any direction. Heads with separately adjusting knobs for tilts–front to back and side to side–enable the user to finely tune his photographic composition in one dimension without running the risk of losing the desired angle in another dimension. This could easily happen with the ball and socket head loosened for finer adjustment.

Once the camera and tripod are in position to take a photograph, the worker may find that focusing the camera lens can not be accomplished without moving the entire system–tripod and all, forward or backward a short distance. One can avoid the need for picking up the tripod and moving it up or back a few millimeters by the use of a focusing rail mounted between the camera and tripod (or between camera and tripod horizontal arm). These gadgets enable, for example, up to 6 cm movement of the camera forward or backward without having to move or readjust the tripod or its horizontal arm.

LIGHTING

Natural daylight offers a big challenge to the wildflower photographer. Sunlight quality changes during the day, influencing the color rendition of the same flower. Morning and evening light are stronger in the red and orange ends of the spectrum while near noon the blue colors tend to be more apparent. Some feel that mid-day offers an unfavorable time for wildflower photography because of the light characteristics and the sun's angle. Theoretically, morning and evening light are identical–given the sun at equivalent angles in the east and west. However, mornings seem to offer certain advantages over evening with light of the same quality and intensity. This has not so much to do with the light itself but the condition of the plants. Wildflowers appear freshest in the morning before the dew evaporates. The orientation of the flower or plant may dictate the time of day when available light is best for photography.

Brilliant, sunny, cloudless days do not generally offer the best light conditions for wildflower photography. Harsh tones and dark shadows usually result. Color rendition of flowers is generally best on days with a slight haze or light cloud cover. The kind of clouds, their density, and their altitude all influence the quality of light. On days when sunlight is intense (or on windy days) the photographer may want to cover the subject (and himself) with a translucent but not transparent plastic "tent" of about 3 mils thickness. This has the effect of diffusing the light and causing the shadows to be less harsh. It should always be kept in mind that color films can withstand latitudes in exposure only a fraction of that possible for black and white film. This means that for color film there are greater risks of underexposure and overexposure where bright light and hard shadows prevail.

We have, on occasion, resorted to using reflectors to provide more equal illumination on the subject. A wrinkled piece of aluminum foil taped around a cardboard measuring about 30 cm by 45 cm is adequate. This has the effect of placing reflected sunlight onto plants growing in shaded situations or it may be used to reduce but not completely eliminate harsh shadows among otherwise adequately illuminated plants. More sophisticated reflector umbrellas on special tripods are available for those interested.

Where light conditions call for exposures much longer than about ½ second, color films usually fail to reproduce colors faithfully. This perfectly normal film trait is usually treated under the subject of "reciprocity characteristics" and specific data for each film type are available from the film manufacturer. In poorly lighted situations of certain natural settings one may require artificial illumination such as electronic flash.

Powerful electronic flash units may be too bright at very close ranges without a light diffuser which can easily be improvised by using 1-2 layers of an ordinary white handkerchief stretched over the light source. Some electronic flash units consist of a ring light which surrounds the camera lens, producing equal illumination on all sides. Equal illumination with such a light system is somewhat of a drawback since images often appear flat and lack a feeling of depth. One could perhaps experiment by placing varying amounts of masking tape over the ring light on one side, or by removing the ring light from the lens and holding it to one side in order to provide slightly unequal illumination on the subject thus returning some feeling of depth to the photograph.

Now available are automatic controls for certain electronic flash units which measure the amount of reflected light from the subject and turn the flash off when ample light has been received on the film. Such automatic controls have certain limitations. For example, the closer you get to the subject, the more difficult it may become to get "automatic" results. Automatic units, nevertheless, help insure the likelihood of correct exposure in different situations.

Proper subject lighting will continue to be one of the greatest challenges to the novice as well as to the expert. Probably most wildflower photographs are taken with the light coming from behind the photographer onto the front of the subject. This is termed front lighting. Back lighting results when the major light source is from the rear of the subject or more commonly above and behind the subject. Wildflowers illuminated by backlighting and sidelighting often exhibit a rim of light around their periphery and make an entirely different impression on the viewer—especially when transmitted light comes through the flower parts. A variety of types of lighting provides for interesting viewing.

Measurement of light for the exposure is accomplished by the use of exposure meters. Most 35 mm cameras have a built-in through-the-lens light meter. The most specific light measurements are made by a "spot meter" which measures reflected light on a small spot included within the field of view. Many people prefer "averaging meters" which give a light reading based partly on the central spot region with the remainder of the field providing the rest of light for meter registry. The best built-in meters approach in quality that of the hand-held meters. Of course, with automatic cameras the light is metered automatically and the meter is coupled to lens aperture to insure proper exposure, theoretically, every time. The creative photographer may want to orerride automatic meter readings to compensate for contrasty situations such as very light or dark background, or when one part of the subject is usually light or dark.

FILTERS

Many photographers keep an ultraviolet or haze filter over each camera lens—more to serve as a protection from dust and breakage than for its ability to modify light quality albeit ever so slightly. If any other filter is to be used for color work the choice should be for a polarizing filter. It is the one filter which can help intensify saturation of almost all flower colors. On film it can also help remove excess glare from water surfaces and to darken skies. Both of these phenomena are due to effects of polarized light.

Black and white photographs of vegetation can often be rendered in more shades of gray with the use of a yellow-green or a medium yellow filter. Both filters help to lighten green foliage which may have a tendency to appear too dark on the photographic print. It should be pointed out that many "purists" refuse the use of all filters for any purpose and still get remarkable results!

COMPOSITION

The possession of a critical eye for detail in composition often helps separate the photographs of the novice from those of the experienced photographer, since both may use the same kind of equipment and film. Photographs are *made*; not taken. In close-up photography, one should give special attention to the background. Those who place a piece of cloth or other backdrop behind each wildflower subject will have the background problem "mastered"—even if monotonous. Those photographers who like to work with natural environmental backgrounds will have to contend with many parameters that may pose a threat to good photographic composition. Since a camera does not see as does a human eye, the photographer will have to become sensitized to the limitations of his camera to be most effective.

In general, wildflowers are photographed with the camera on the level of the flowers. Too many beginners photograph only from above. Occasionally, optimal camera position may call for the camera facing up on the subject. If 35 mm film is used you will be recording images on a piece of film 24 mm x 36 mm (about 1" x 1½"). This calls for moving in close so that the subject more or less *fills* the field of view. If the intention is to give an impression of the habitat along with the subject (at a reduced scale) the camera placement may be quite different. Many photographers prefer both; first, a photograph of the plant in its native habitat followed by a close-up of the main subject. Including elements of the plant that constitute critical or key characters is helpful—especially if the photograph is to be used for plant identification and not for purely artistic reasons.

While plant litter on the ground is often useful in providing information relating to the habitat, certain brightly-colored dead twigs and leaves or extraneous living plant parts are often the most brilliant objects in the photograph—especially noticeable when using a fast film and bright light. As a test, when you think you have a good slide in hand, try placing it in the projector so that on the screen it is seen upside down. If the most brightly shining objects in the photograph are not part of the main subject you probably have, at best, only a fair photograph. There is no great lesson to be learned in leaving in place *every* leaf, twig, rock, or other potentially distracting element. Slight re-positioning of the camera e.g. to the left or right may help hide or eliminate a highly reflective object in the background. A little judicial "weeding" and removal of litter is often helpful, but be careful not to leave visible stubs of broken parts, newly exposed surfaces where, e.g., a pebble was removed, or other evidence of such "editing." Practice conceptualizing the finished product through the viewfinder eyepiece. Someone has said that photography is a process of isolating—of separating the important from the unimportant.

In the diagram below, which represents a photograph, it is generally advisable to place the main features of photographic interest at points A, B, C, or D. In other words, having the subject exactly centered is not necessarily

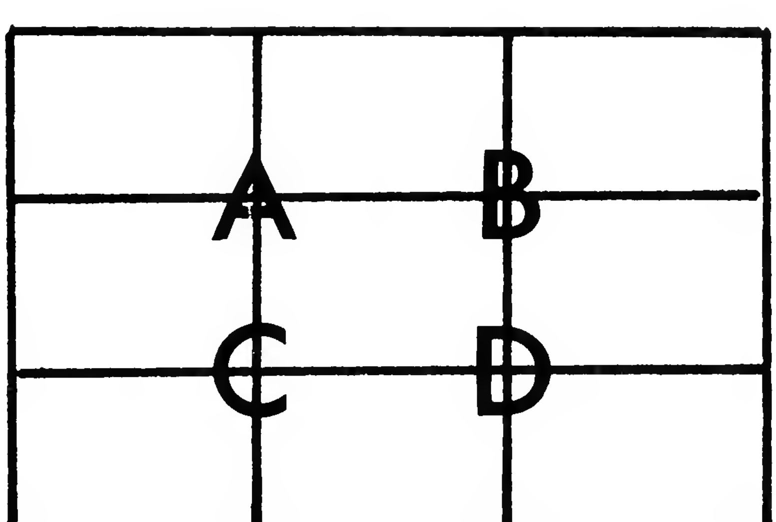

Fig. 1. Line intersections, A, B, C, and D, showing locations of principal foci of photographic interest.

in the best tradition of composition. The same rule applies if the long dimension is in the vertical.

A decision must be made with rectangular film in regard to placement of the longer dimension in the horizontal or in the vertical. The subject height and width, as well as distance from the camera to subject, will all enter into such a decision. If a 0.5 m tall goldenrod is to the photographed and if its basal leaves provide a key character, one might logically select the longer film dimension with a vertical orientation. A broad clump of hepatica might call for a rectangular view with the longer dimension in the horizontal. Many experienced wildflower photographers prefer the vertical to the horizontal format for most flower photographs.

Dr. Robert Poole has reminded us that the human eye tends to react more favorably to an odd number, e.g. 5 or 7, than to an even number such as 6 or 8. This consideration would not be important where large numbers obtain.

A good photographer almost never makes a single attempt at a subject that he really wants to capture on film. A rule of thumb is to expose according to the metered reading then expose again one f stop more than indicated followed by a third exposure at one f stop less. One can also bracket at different f stops to cause the background to be variously out of focus or blurred—often a desirable characteristic for a wildflower photograph. A good way to eliminate distracting background elements is to open the lens, throwing the background out of focus, or to cast a shadow on the background. When habitats are to be shown, greater depth of field (achieved by using smaller lens apertures) would be desirable.

The references below can serve as useful sources for additional information on many of these subjects.

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Editorial Notes

NEW EDITOR AND BOARD: We are very happy to announce that effective with Vol. 16 (1977) the editor of *The Michigan Botanist* will be Dr. Howard Crum, Curator of Bryophytes and Lichens in the University of Michigan Herbarium and Professor of Botany. Since the last number of Vol. 15 will be in press shortly, all manuscripts and editorial communications should henceforth be sent to Howard Crum at the Herbarium, North University Bldg., The University of Michigan, Ann Arbor, Michigan 48109. The new appointment was made by the Board of Directors of the Michigan Botanical Club on March 14, 1976, following a request by the present editor to be relieved after 15 years (and some 3000 printed pages).

Effective in March, we welcomed two new members to the Editorial Board: Ellen Weatherbee of Ann Arbor, instructor on edible plants for University Courses in Adult Education; and Dr. James Pringle, taxonomist at the Royal Botanical Gardens, Hamilton, Ontario. Retiring from the Board after two or more terms of two years each, with the warm gratitude of the editor, are Dr. Ronald L. Stuckey of The Ohio State University and Dr. W. H. Wagner, Jr., of The University of Michigan.

OFFER FOR NEW SUBSCRIBERS ONLY! *The Michigan Botanist* is making a special back-issue offer exclusively to new subscribers. Persons entering a new subscription to begin with Vol. 16 (1977) at $5.00 may purchase the previous six volumes at *half-price*. These six volumes will include the three-year indexes for Vols. 10-12 and Vols. 13-15. The regular price for back volumes is $3.00 through Vol. 13 and $5.00 subsequently. Instead of a price of $22.00 for the six volumes, therefore, this offer makes them available for $11.00 with a $5.00 subscription to Vol. 16.

Checks for $16.00, taking advantage of this substantial discount, should be made payable to The Michigan Botanist and should be sent to the business and circulation manager at 1509 Kearney Rd., Ann Arbor, Michigan 48104. This special offer expires December 1, 1976.

Authors who wish to have original manuscripts or art work returned should notify the editor promptly, before a major housecleaning of the files.

The March number (Vol. 15, No. 2) was mailed March 11, 1976.

News of Botanists

Emil P. Kruschke, who was associated with the Milwaukee Public Museum from 1938 until his retirement in 1964, died on January 24, 1976, at the age of 68. A recognized authority—indeed, the only one—on the hawthorns, *Crataegus*, he had in preparation an extensive revision with keys. An effort will be made by the Museum to publish the portions which were complete. Two earlier contributions on this genus appeared in the Museum's "Publications in Botany" series in 1955 and 1965 (see Mich. Bot. 4: 93-96). Mr. Kruschke also published over 30 popular and semi-technical articles.

Bernard Horne, of Jackson, Michigan, died at the age of 73 on January 29, 1976. An accomplished and serious amateur in botany and a skillful photographer, with a special concern for orchids, his color photographs have appeared in *Michigan Flora, Wildflowers and Weeds,* and the multi-volumed *Wild Flowers of the United States.*

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(On the cover: A bog in Luce County, Michigan, about one mile east of Pike Lake, photographed June 30, 1972, by T. L. Mellichamp.)

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Vol. 15, No. 4

THE MICHIGAN BOTANIST

October, 1976

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Back issues beginning with Vol. 14 are $5.00 per volume ($1.25 per number). Complete sets and sets beginning with Vol. 2 are available. On these, as on any order totalling 20 or more copies, a 25% discount is allowed.

Subscriptions (from those not members of the Michigan Botanical Club) and all orders for back issues should be addressed to the business and circulation manager.

Address changes from Botanical Club members should be sent only to appropriate chapter officers. Address changes for *non-member subscribers only* should be sent to the business and circulation manager. Send *no* address changes to the editor.

Articles dealing with any phase of botany relating to the Upper Great Lakes Region may be sent to the editor in chief. In preparing manuscripts, authors are requested to follow our style and the suggestions in "Information for Authors" (Vol. 15, p. 238).

THE MICHIGAN BOTANICAL CLUB

Membership in the Michigan Botanical Club is open to anyone interested in its aims: conservation of all native plants; education of the public to appreciate and preserve plant life; sponsorship of research and publication on the plant life of the State; sponsorship of legislation to promote the preservation of Michigan native flora and to establish suitable sanctuaries and natural areas; and cooperation in programs concerned with the wise use and conservation of all natural resources and scenic features.

Dues are modest, but vary slightly among the chapters and with different classes of membership. Persons desiring to become state members (not affiliated with a local chapter, for which secretaries or other contact persons are listed below) may send $5.00 dues to the Membership Chairman listed below. In all cases, dues include subscription to THE MICHIGAN BOTANIST. (Persons and institutions desiring to subscribe without becoming members should deal with the business and circulation manager as stated at the top of this page.)

A BOTANICAL INVENTORY OF SANDHILL WOODLOT, INGHAM COUNTY, MICHIGAN II. CHECKLIST OF VASCULAR PLANTS

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A vegetational analysis of Sandhill Woodlot was published previously (Frye, 1976). The following checklist includes the vascular plants which occur in the woodlot. Most species were collected in more than one stage of development. All collection numbers are Valasek collections unless designated otherwise. Collections cited are deposited in the Beal-Darlington Herbarium, Michigan State University.

Names preceded by an asterisk are of non-indigenous species. Dates indicate the flowering date of the angiosperms based on specimens in the Beal-Darlington Herbarium from the southern half of the Lower Peninsula of Michigan.

The systematic arrangement is as follows: Pteridophyte and gymnosperm higher taxa, Cronquist et al. (1966); pteridophyte and gymnosperm families, Melchior and Werdermann (1954); angiosperms, Cronquist (1968); genera and species of each family, alphabetical.

The checklist includes 73 families, 175 genera, and 255 species. The largest families are the Compositae with the 16 genera and 21 species and the Gramineae with 13 genera and 19 species. The largest genus is *Carex* with 16 species.

EQUISETOPHYTA (Horsetails)

EQUISETACEAE (Horsetail Family)

Equisetum arvense L. Horsetail. 556, 683. Along the drainage ditch and pond edges.
E. hyemale L. Scouring rush. 603, 658. Along the drainage ditch.

POLYPODIOPHYTA (Ferns)

OPHIOGLOSSACEAE (Adder's-tongue Family)

Botrychium virginianum (L.) Sw. Rattlesnake fern. 620, 772. Scattered through the woods.

POLYPODIACEAE (Polypody Family)

Adiantum pedatum L. Maidenhair fern. 636. Infrequently scattered through the woods.
Athyrium asplenioides (Michx.) Desv. Lady fern. 637, 851, 878. Frequent in the central portion.
A. pycnocarpon (Spreng.) Tidest. Narrow-leaved spleenwort. 856. Central portion.
A. thelypteroides (Michx.) Desv. Silvery spleenwort. 748, 757. Central portion.
Cystopteris fragilis (L.) Bernh. Fragile fern. 684. SE portion.
Dryopteris spinulosa (O. F. Muell.) Watt. Spinulose shield-fern. 630. Scattered through the woods.
Onoclea sensibilis L. Sensitive fern. 615. Near the vernal ponds.
Polystichum acrostichoides (Michx.) Schott. Christmas fern. 638. Scattered through the woods.

Thelypteris hexagonoptera (Michx.) Weatherby. Broad beech-fern. 877. E-central portion.

T. noveboracensis (L.) Nieuw. New York fern. 826. N-central portion near the vernal pond.

PINOPHYTA (Gymnosperms)

PINACEAE (Pine Family)

**Pinus sylvestris* L. Scotch pine. 797. Single tree along the edge of the E-central portion.

MAGNOLIOPHYTA (Angiosperms)

MAGNOLIATAE (Dicotyledons)

MAGNOLIIDAE

MAGNOLIACEAE (Magnolia Family)

Liriodendron tulipifera L. Tulip-poplar. 888. Few saplings in the NW corner. June.

LAURACEAE (Laurel Family)

Lindera benzoin (L.) Blume. Spicebush. 509, 512, 809, 850, 883. Scattered through the woods in low areas. April.

RANUNCULACEAE (Crowfoot Family)

Actaea pachypoda Ell. White baneberry. 599, 835. Scattered through the woods. May-June.

Anemone quinquefolia var. *interior* Fern. Wood anemone. 802. Near the vernal pond in the E-central portion. April-May.

Caltha palustris L. Marsh-marigold. 663, 537. Vernal pond in the E-central portion. April-June.

Hepatica acutiloba DC. Liverleaf. 508, 686, 936. Patches in the SE and central portions. April-May.

Isopyrum biternatum (Raf.) T. & G. False rue-anemone. 503, 517, 549, 580, 896, Flanders 251. Abundantly scattered through the woods. April-May.

Ranunculus abortivus L. Small-flowered crowfoot. 561, 742. Scattered through the woods. May-June.

R. recurvatus Poir. 604, 746. Scattered through the woods. May-June.

R. sceleratus L. Cursed crowfoot. 939. Pond in the W-central portion. May-June.

Thalictrum dasycarpum Fisch. & Avé-Lall. Purple meadow-rue. 651. S-central portion. June-July.

T. dioicum L. Meadow-rue. 690. SE portion. April-May.

BERBERIDACEAE (Barberry Family)

**Berberis thunbergii* DC. Japanese barberry. 597. Central portion. April-May.

Caulophyllum thalictroides (L.) Michx. Blue cohosh. 530, 792. Scattered through the woods. April-May.

Podophyllum peltatum L. May-apple. 600, 770. Scattered through the woods in patches. May.

MENISPERMACEAE (Moonseed Family)

Menispermum canadense L. Moonseed. 859. Central portion. June-July.

PAPAVERACEAE (Poppy Family)

Sanguinaria canadensis L. Bloodroot. 505, 582. Scattered through the woods in patches. April-May.

FUMARIACEAE (Fumitory Family)

Dicentra canadensis (Goldie) Walp. Squirrel-corn. 511, 526, Flanders 245, 248. Abundantly scattered through the woods in patches. April-May.

D. cucullaria (L.) Bernh. Dutchman's breeches. 507, 518, 551, Flanders 246. Scattered through the woods in patches. April-May.

HAMAMELIDAE

HAMAMELIDACEAE (Witch-hazel Family)

Hamamelis virginiana L. Witch-hazel, 922. Infrequent in the central portion. September-October.

ULMACEAE (Elm Family)

Celtis occidentalis L. Hackberry. 884. E-central portion. May.

Ulmus americana L. American elm. 566, 574, 855. Scattered through the woods. April.

U. rubra Muhl. Slippery or red elm. 905. Scattered through the woods. April-May.

U. thomasi Sarg. Rock elm. 520, 629. Scattered through the woods. April-May.

MORACEAE (Mulberry Family)

**Morus alba* L. var. *tatarica* (L.) Ser. White mulberry. 689, 800, 946. Few trees along the E-central edge. May.

URTICACEAE (Nettle Family)

Laportea canadensis (L.) Gaud. Wood-nettle. 858. Dense colonies in the moist areas. June-August.

Urtica gracilis Ait. Nettle. 928. Near the vernal ponds in the central portion. July-August.

JUGLANDACEAE (Walnut Family)

Carya cordiformis (Wang.) K. Koch. Bitternut hickory. 874. Scattered through the woods. May.

C. ovalis (Wang.) Sarg. Pignut hickory. 920. SW portion. May-June.

Juglans nigra L. Black walnut. 796, 919, 921. Infrequent in the SW portion. May.

FAGACEAE (Beech Family)

Fagus grandifolia Ehrh. Beech. 570, 799, 945. One of the dominant trees. May.

Quercus alba L. White oak. 942. Scattered thorugh the woods. May.

Q. macrocarpa Michx. Mossy-cup or bur oak. 699, 915. Scattered through the woods. May.

Q. muehlenbergii Engelm. Chestnut oak. 913. E-central portion. May-June.

Q. rubra var. *borealis* (Michx.f.) Farw. Northern red oak. 572. Scattered through the woods. May.

Q. velutina Lam. Black oak. 592. SW corner near the younger portion of the woods. May.

BETULACEAE (Birch Family)

Carpinus caroliniana Walt. Ironwood or blue-beech. 853, 951. Scattered through the woods. April-May.

Corylus americana Walt. Hazel. 696. Young tree on the W edge of the pond in the W-central portion. April-May.

Ostrya virginiana (Mill.) K. Koch. Ironwood or hop-hornbeam. 575, 947. Scattered through the woods. April-May.

CARYOPHYLLIDAE

PHYTOLACCACEAE (Pokeweed Family)

Phytolacca americana L. Pokeweed. 927. SE corner. June-October.

CARYOPHYLLACEAE (Pink Family)

**Cerastium vulgatum* L. Mouse-eared chickweed. 675. E-central portion. May-July.

**Dianthus armeria* L. Deptford pink. 777. Along the W edge. Late June-early August.

**Lychnis alba* Mill. White cockle. 735. Along the edges. May-October.

Stellaria longifolia Muhl. Chickweed. 691. SE portion. May-July.

PORTULACACEAE (Purslane Family)

Claytonia virginica L. Spring beauty. 506, 567, 558, Flanders 247. Scattered abundantly through the woods. March-May.

POLYGONACEAE (Buckwheat Family)

Polygonum persicaria L. Smartweed. 934. SE corner. July-September.

P. virginianum L. Jumpseed. 886, 891. Scattered through the woods. July-August.

**Rumex acetosella* L. Red sorrel. 676. Along the edges. May-July.

**R. crispus* L. Yellow dock. 710. Along the edges. June.

DILLENIIDAE

GUTTIFERAE (St. John's wort Family)

**Hypericum perforatum* L. St. John's-wort. 778. Along the W edge. June-July.

TILIACEAE (Linden Family)

Tilia americana L. Linden or basswood. 571, 688, 953. Abundantly scattered through the woods. May-June.

VIOLACEAE (Violet Family)

Viola canadensis L. Canada violet. 544, 623, 840. Abundantly scattered through the woods. Mostly May-June but sporadically April-October.

V. pubescens var. *eriocarpa* (Schwein.) Russell. Yellow violet. 525, 602, 731, 880. Abundantly scattered through the woods. April-June.

V. rostrata Pursh. Long-spurred violet. 521, 529, 546. Infrequently scattered through the woods. April-May.

V. sororia Willd. Blue violet. 538, 545, 624. Abundantly scattered through the woods. April-June.

CUCURBITACEAE (Gourd Family)

Echinocystis lobata (Michx.) T. & G. Prickly cucumber. 930. Along the S-central edge near the pine plantation. August.

SALICACEAE (Willow Family)

Populus deltoides Marsh. Cottonwood. 648, 758. Scattered through the moister portions of the woods. April-May.

P. tremuloides Michx. Quaking aspen. 634, 910. Scattered through the woods. One of the dominant trees in the SW portion. April.

Salix discolor Muhl. Pussy willow. 527, 541, 543. Along the SW edge near the younger portion of the woods. April-May.

S. rigida Muhl. Heart-leaved willow. 540, 542, 652, 667, 668, 703. S portion. April-May.

CRUCIFERAE (Mustard Family)

**Barbarea vulgaris* R. Br. Yellow rocket or winter cress. 589, 753. Along the edges. May-August.

**Berteroa incana* (L.) DC. Hoary alyssum. 866. Along the S edge. June-early November.

Cardamine bulbosa (Schreb.) BSP. Spring cress. 606. N edge of the pond in the E-central portion. April-early June.

C. douglassii (Torr.) Britt. Bitter cress. 523, 534, 547, 605. Near the vernal ponds in the central portion. April-May.

Dentaria laciniata Muhl. Toothwort. 522, 745. Scattered through the woods. April-May.

**Lepidium campestre* (L.) R. Br. Field cress or peppergrass. 729. E of the pine plantation. May-June.

**Thlaspi arvense* L. Penny-cress or fanweed. 672. Along the E-central portion. April-July.

MONOTROPACEAE (Monotropa Family)

Monotropa uniflora L. Indian pipe. 595, 890. E-central portion near the trail. July-August.

PRIMULACEAE (Primrose Family)

Lysimachia ciliata L. Loosestrife. 805. NW corner. June-August.

ROSIDAE

GROSSULARIACEAE (Gooseberry Family)

Ribes americanum Mill. Wild black currant. 717. SE edge in moist soil. May-June.

R. cynosbati L. Prickly gooseberry. 555, 598, 642. Scattered through the woods. May.

SAXIFRAGACEAE (Saxifrage Family)

Mitella diphylla L. Bishop's cap. 554, 654. Near the ponds. Late April-early June.

Saxifraga pensylvanica L. Saxifrage. 649. SE portion near the pine planation. May-June.

ROSACEAE (Rose Family)

Agrimonia gryposepala Wallr. Agrimony. 824, 893. Along the trail in the central portion and in the NW corner. July.

Amelanchier arborea (Michx.f.) Fern. Serviceberry. 557. Infrequent along the W-central edge. April-May.

A. laevis Wieg. Serviceberry. 947. Infrequent along the W-central edge. Late April-early May.

Crataegus macrosperma Ashe. Hawthorn. 914, 918. E-central portion. May-June.

C. punctata Jacq. Hawthorn. 908, 954. Central portion. May-early June.

Fragaria virginiana Duchesne. Strawberry. 588. Along the W edge. May-June.

Geum canadense Jacq. Avens. 759, 765, 791, 798. Scattered through the woods. June-August.

**Malus pumila* Mill. Apple. 593, 794. Infrequent in the SW corner near the younger portion of the woods. May.

**Potentilla recta* L. Five-finger cinquefoil. 728, 775. Along the edges. June-August.

Prunus serotina Ehrh. Black cherry. 573, 587, 779, 887, 949. Abundantly scattered through the woods. May.

P. virginiana L. Choke cherry. 697, 837, 909, 916. SW corner near the younger portion of the woods. May-early June.

Rosa carolina L. Rose. 906. Along the SE edge. June-July.

**R. multiflora* Thunb. 810, 948. SE edge of the pond in the E-central portion and the N edge. June.

Rubus allegheniensis Porter. Common blackberry. 762. Along the path in the SW portion. May-June.

R. occidentalis L. Black raspberry. 803. Along the E edge. May-June.

R. strigosus Michx. Red raspberry. 632, 808, 812, 849. Along the edges. June-July.

LEGUMINOSAE (Pea Family)

Amphicarpa bracteata (L.) Fern. Hog-peanut. 737. Scattered through the woods. July-September.

Desmodium canadense (L.) DC. Tick trefoil. 865, 868. Along the S edge. July-August.

**Melilotus officinalis* (L.) Desr. Yellow sweet-clover. 804. Along the E edge. June-September.

**Trifolium pratense* L. Red clover. 839. Along the edges. June-October.

ONAGRACEAE (Evening-primrose Family)

Circaea quadrisulcata var. *canadensis* (L.) Hara. Enchanter's nightshade. 793, 838, 895. Scattered through the woods. June-early August.

Oenothera biennis L. Evening-primrose. 848. Along the N edge. July-September.

CORNACEAE (Dogwood Family)

Cornus alternifolia L. f. Alternate-leaved dogwood or green osier. 680, 681, 687, 852. Scattered through the woods. May-June.

C. florida L. Flowering dogwood. 944. Infrequent in the central portion. May.

C. racemosa Lam. Panicled dogwood. 861, 952. Scattered through the woods. May-June.

C. stolonifera Michx. Red osier. 664. Near the vernal pond in the E-central portion. May-June infrequently July-August.

CELASTRACEAE (Staff Tree Family)

Euonymus obovatus Nutt. Running strawberry-bush. 617. Infrequently scattered through the woods. May-June.

AQUIFOLIACEAE (Holly Family)

Ilex verticillata (L.) Gray. Black alder or winterberry. 747. Near the vernal pond in the E-central portion. June-July.

VITACEAE (Grape Family)

Parthenocissus quinquefolia (L.) Planch. Virginia creeper or American ivy. 661. Scattered through the woods. June.

Vitis riparia Michx. Frost grape. 666, 815, 924a. Scattered through the woods, often forming extensive vine systems. May-June.

ACERACEAE (Maple Family)

Acer negundo L. Box-elder. 678. Infrequent along the E-central edge. April-May.

A. nigrum Michx. f. Black maple. 941. Abundantly scattered through the woods. April-early May.

A. rubrum L. Red maple. 504, 923. Infrequently scattered through the woods. April-early May.

A. saccharinum L. Silver maple. 528. 601. Frequent in wet areas near the vernal ponds. April-early May.

A. saccharum Marsh. Sugar maple. 533, 567, 569. Dominant tree through most of the woods. April-May.

ANACARDIACEAE (Cashew Family)

Rhus typhina L. Staghorn sumac. 769, 782, 783, 789. Along the edges and in the areas of young forest. June.

Toxicodendron radicans (L.) Ktze. Poison-ivy. 730. Scattered through the woods. June.

RUTACEAE (Rue Family)

Zanthoxylum americanum Mill. Prickly-ash. 535, 665. Scattered through the woods. Forms a large thicket in the E-central portion. May.

OXALIDACEAE (Wood-sorrel Family)

Oxalis stricta L. Wood-sorrel. 750. At the E-central entrance. May-August.

GERANIACEAE (Geranium Family)

Geranium maculatum L. Cranesbill. 590, 608a, 613, 738, 818. Scattered through the woods. May-early June.

BALSAMINACEAE (Touch-me-not Family)

Impatiens capensis Meerb. Spotted touch-me-not. 873. Near the vernal pond in the E-central portion. July-September.

ARALIACEAE (Ginseng Family)

Aralia racemosa L. Spikenard. 889. E-central portion. July.

Panax trifolius L. Dwarf ginseng. 577. Few scattered patches in the NE corner. April-May.

UMBELLIFERAE (Parsley Family)

Angelica atropurpurea L. Angelica. 711. Along the SE edge in moist soil. Late May-early July.

Cryptotaenia canadensis (L.) DC. Honewort. 660, 882. Scattered through the woods. June-July.

**Daucus carota* L. Wild carrot or Queen Anne's lace. 801. Along the edges. June-October.

Erigenia bulbosa (Michx.) Nutt. Harbinger-of-spring. 500, 553, 621. Scattered through the woods. April.

Osmorhiza claytonii (Michx.) Clarke. Sweet cicely. 743. Scattered through the woods. May-June.

Sanicula gregaria Bickn. Black snakeroot. 643. Scattered through the woods. May-early July.

S. trifoliata Bickn. Black snakeroot. 677, 740, 876, 937. Scattered through the woods. Late May-early June.

Sium suave Walt. Water parsnip. 586, 640, 864, 872. In the pond in the W-central portion. July-October.

**Torilis japonica* (Houtt.) DC. Hedge-parsley. 842. Near the trail in the E-central portion. July-August.

ASTERIDAE

APOCYNACEAE (Dogbane Family)

Apocynum cannabinum L. Indian-hemp. 712. Along the SE edge. May-September.

ASCLEPIDACEAE (Milkweed Family)

Asclepias syriaca L. Common milkweed. 785. Along the S edge. June-August.

SOLANACEAE (Nightshade Family)

Physalis subglabrata Mackenz. & Bush. Ground cherry. 806. Along the E-central edge. July-August.

**Solanum carolinense* L. Horse nettle. 931. Along the S-central portion near the pine plantation. June-August.

**S. dulcamara* L. Red nightshade. 827. Near the vernal pond in the N-central portion. June-mid-August.

POLEMONIACEAE (Phlox Family)

Phlox divaricata L. Phlox. 562, 744. Scattered through the woods. April-June.

HYDROPHYLLACEAE (Waterleaf Family)

Hydrophyllum appendiculatum Michx. Waterleaf. 653. Scattered through the woods. May-July.

H. canadense L. Waterleaf. 767. Scattered through the N portion. June.

H. virginianum L. Waterleaf. 619, 662, 749. Scattered through the woods in large patches. May-early June.

BORAGINACEAE (Borage Family)

Hackelia virginiana (L.) Johnst. Stickseed. 912. Infrequent in the W-central portion. July-August.

PHRYMACEAE (Lopseed Family)

Phryma leptostachya L. Lopseed. 814, 836, 894. Scattered through the woods. June-August.

VERBENACEAE (Vervain Family)

Verbena hastata L. Vervain. 822. Along the SW edge near the young forest. Late June-September.

V. urticifolia L. White vervain. 843. Infrequently scattered through the woods. July-early August.

LABIATAE (Mint Family)

**Leonurus cardiaca* L. Motherwort. 784. Along the trail in the central portion. June-July.

Lycopus virginicus L. Water-horehound. 899. Edge of the pond in the W-central portion. July-September.

Monarda fistulosa L. Horse-mint. 833. Along the SW edge. July-August.

Prunella vulgaris L. Heal-all. 766. Near the SW entrance. June-October.

Scutellaria lateriflora L. Mad-dog skullcap. 870, 903. Along the pond in the W-central portion. May-August.

Teucrium canadense L. Wood-sage. 867. Along the S edge. July-September.

PLANTAGINACEAE (Plantain Family)

**Plantago lanceolata* L. Ribgrass or buckhorn. 716, 780. Along the edges. May-June.

**P. major* L. Common plantain. 834. At the W-central entrance. July-October.

OLEACEAE (Olive Family)

Fraxinus americana L. White ash. 811, 823, 854, 924. One of the dominant trees in the woods. May.

F. nigra Marsh. Black ash. 956. Wet areas of the woods. May-June.

SCROPHULARIACEAE (Figwort Family)

Veronica scutellata L. Marsh speedwell. 734, 760. Along the SW edge of the pond in the W-central portion. June-July.

V. serpyllifolia L. Speedwell. 614. At the SW entrance. May-June.

OROBANCHACEAE (Broom-rape Family)

Epifagus virginiana (L.) Bart. Beech-drops. 829, 907. Parasitic on the beech in the N portion. July-October.

CAMPANULACEAE (Bluebell Family)

Lobelia inflata L. Indian-tobacco. 879. E-central portion. August-September.

L. syphilitica L. Blue cardinal-flower. 875. Infrequent in the E-central portion. August-early October.

RUBIACEAE (Madder Family)

Cephalanthus occidentalis L. Buttonbush. 845. In the vernal ponds. June-August.

Galium aparine L. Cleavers. 559, 616. Abundantly scattered through the woods often forming dense mats. May-June.

G. lanceolatum Torr. Bedstraw. 755. Central portion. June-July.

G. obtusum Bigel. Bedstraw. 752. Central portion. June.

G. triflorum Michx. Sweet-scented bedstraw. 732, 741. Central portion. May-July.

Mitchella repens L. Partridge-berry. 938. Near the NW corner of the pond in the W-central portion. June-July.

CAPRIFOLIACEAE (Honeysuckle Family)

**Lonicera morrowi* Gray. Honeysuckle. 820. Along the W edge. May-June.

Sambucus canadensis L. Common elder. 786. In moist areas. May-June.

S. pubens Michx. Red berried elder. 560, 813. Scattered through the woods. Late April-June.

Viburnum acerifolium L. Arrow-wood or maple-leaved viburnum. 647, 693. SE portion. May-June.

V. lentago L. Wayfaring tree. 925. Central portion. May-June.

V. prunifolium L. Black haw. 698, 857. SE and central portions. June.

V. trilobum Marsh. Highbush-cranberry. 926. SE corner. May-July.

COMPOSITAE (Composite or Aster Family)

Achillea millefolium L. Common yarrow. 645. Along the SW edge. May-October.

Antennaria neglecta Greene. Pussy-toes. 565. Along the W edge. May.

A. plantaginifolia (L.) Richards. 581, 663, 756. Along the W edge. May.

Aster cordifolius L. 898. Infrequently scattered through the woods. August-October.

A. lateriflorus (L.) Britt. Calico aster. 901. Scattered through the woods. July-early October.

**Arctium minus* (Hill) Bernh. Common burdock. 830, 847. Along the edges. July-August.

Bidens comosa (Gray) Wieg. Beggar-ticks. 902. In the vernal ponds. August-September.

**Chrysanthemum leucanthemum* L. Ox-eye daisy. 715, 768. Along the edges. Late May-July.

**Cichorium intybus* L. Common chicory. 790. Along the edges. June-October.

**Cirsium vulgare* (Savi) Tenore. Bull thistle. 885, 932, 940. NW corner. July-October.

Erigeron annuus (L.) Pers. Daisy-fleabane. 714, 727. Along the edges. June-early October.

E. philadelphicus L. Fleabane. 673, 713. Along the edges. May-June.

Helianthus decepetalus L. Sunflower. 863, 892a. At the E-central entrance. July-early September.

**Hieracium aurantiacum* L. King-devil. 674. Along the edges. June-August.

H. pratense Tausch. Hawkweed. 679. Along the edges. Late May-August.
Rudbeckia hirta L. Black-eyed Susan. 774, 841. Along the edges. June-August.
Senecio aureus L. Squawweed. 591, 685. W-central portion. May-June.
Solidago caesia L. Blue-stem goldenrod. 900. Along the trail in the W-central portion. Late August-early October.
S. flexicaulis L. Goldenrod. 935. Along the S edge. July-September.
**Taraxacum officinale* Weber. Dandelion. 564. Along the edges. April-October.
**Tragopogon pratensis* L. Goat's beard. 787. SE portion. June-early July.

LILIATAE (Monocotyledons)

COMMELINIDAE

JUNCACEAE (Rush Family)

Juncus tenuis Willd. Path rush. 733, 763, 764. Along the edges. June-August.

CYPERACEAE (Sedge Family)

Carex albursina Sheldon. 550, 625. Scattered through the woods May-July.
C. blanda Dewey. 610, 612, 694. Scattered through the woods. May-June.
C. convoluta Mackenz. 682, 695, 816. Scattered through the woods. Late May-July.
C. crinita Lam. 639. Along the ponds. Late May-early July.
C. gracillima Schw. 609a. Along the pond in the E-central portion. May-June.
C. hirtifolia Mackenz. 563. Scattered through the woods. May-June.
C. intumescens Rudge. 751. Low area in the central portion. May-July.
C. laxiflora Lam. 671. Along the E-central edge. May-early June.
C. lupulina Muhl. 700, 760a, 761, 771. Near the ponds in the central portion. June-August.
C. molesta Mackenz. 692. SE portion. June-July.
C. pedunculata Muhl. 510. 524. Central portion. May-June.
C. plantaginea Lam. 501, 514, 519, 608. Scattered through the woods. April-May.
C. prasina Wahl. 583. N-central portion. May.
C. rosea Schk. 579. N-central portion. May-June.
C. stipata Muhl. 611, 641. Near the ponds in the central portion. June-July.
C. woodii Dewey. 513. Scattered through the woods. April-May.
Scirpus cyperinus (L.) Kunth. Wool-grass. 871, 897. In the ponds in the central portion. July-August.

GRAMINEAE (Grass Family)

**Agropyron repens* (L.) Beauv. Quack grass. 788. Along the edges. June-August.
Alopecurus aequalis Sobol. Foxtail. 704. NE edge of the pond in the central portion. Late May-June.
**Bromus inermis* Leyss, Brome grass. 718. Along the S edge. June-July.
**Dactylis glomerata* L. Orchard grass. 626. At the SW entrance. June-August.
Echinochloa muricata (Beauv.) Fern. Barnyard grass. 933. SE corner. August-September.
Elymus riparius Wieg. Wild rye. 881. E-central portion. August.
E. villosus Muhl. Wild rye. 862. E-central portion. July-August.
Festuca obtusa Biehler. Fescue. 807. E-central portion. June-July.
Glyceria septentrionalis Hitchc. 754, 776, 795. SW edge of the pond in the central portion. June-July.
G. striata (Lam.) Hitchc. Manna grass. 656. Near the vernal pond in the E-central portion. June-July.
Leersia virginica Willd. White grass. 892. Along the trail in the W-central portion. August-September.
Panicum implicatum Scribn. Panic grass. 781. Along the W-central edge. June-August.
Phalaris arundinacea L. Reed canary grass, 655, 706, 738. Near the pond in the E-central portion and along the drainage ditch. May-July.
**Phleum pratense* L. Timothy. 739. Along the edges. June-August.
Poa alsodes Gray. 669. SW portion. May-June.
**P. annua* L. Spear grass. 609. Along the vernal pond in the E-central portion. June-October.

P. nemoralis L. 618. SE portion. June-August.

P. pratensis L. Kentucky bluegrass. 627. SW portion. July-August.

Sphenopholis intermedia (Rydb.) Rydb. 644. Along the path in the SW portion. June.

TYPHACEAE (Cat-tail Family)

Typha angustifolia L. Narrow-leaved cat-tail. NE corner of the pond in the central portion. Late June-August.

ARECIDAE

ARACEAE (Arum Family)

Arisaema triphyllum (L.) Schott. Jack-in-the-pulpit or Indian-turnip. 552, 825. Scattered through the woods. Late April-June.

Symplocarpus foetidus (L.) Nutt. Skunk-cabbage. 536. Vernal pond in the E-central portion. April.

LEMNACEAE (Duckweed Family)

Lemna minor L. Duckweed. 709. Pond in the W-central portion. June-August.

L. trisulca L. Star duckweed. 707. Pond in the W-central portion. June-August.

Spirodela polyrhiza (L.) Schleiden. Duckweed. 943. Ponds in the central portion. June-August.

LILIIDAE

LILIACEAE (Lily Family)

Allium tricoccum Ait. Wild leek. 515, 911. Scattered through the woods in patches. July-August.

**Asparagus officinalis* L. Asparagus. 773. Near the SW entrance. May-June.

Erythronium americanum Ker. Yellow adder's tongue. 516, 578. Scattered through the woods. April-May.

Lilium michiganense Farw. Michigan lily. 860. S end of the vernal pond in the E-central portion. June-July.

Maianthemum canadense Desf. Canada mayflower. 635. Sparse colony in the NE portion, May-June.

Polygonatum pubescens (Willd.) Pursh. Small Solomon's seal. 594, 702. Infrequently scattered through the woods. May-June.

Smilacina racemosa (L.) Desf. False Solomon's seal. 622, 828. Scattered through the woods. May-June.

S. stellata (L.) Desf. False Solomon's seal. 607. Near the vernal pond in the E-central portion. May-June.

Trillium grandiflorum (Michx.) Salisb. Trillium. 539, 548. Scattered through the woods. April-May.

IRIDACEAE (Iris Family)

Iris virginica L. var. *shrevei* (Small) Anderson. Iris. 657, 701. Along the vernal ponds in the central portion. June.

SMILACACEAE (Greenbrier Family)

Smilax tamnoides L. var. *hispida* (Muhl.) Fern. Bristly greenbrier. 650a, 955. Scattered through the woods. June.

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Nature education feature --

FORCING NORTHERN WOODY PLANTS INTO FLOWER

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Those of us who teach systematic botany in the winter months in the northern United States know how hard it is to obtain fresh living material for laboratory demonstrations and dissections. Many herbaceous plants can be purchased from florists or grown as hot-house plants, grown from seed in the greenhouse (Mellichamp, 1976), dug from nature and forced as pot plants (Rosendahl, 1914; Mellichamp, 1976), or collected fresh and frozen (Rollins, 1950). However, there is a rich source of woody plant material which can be used if one has the facilities and patience for forcing it out of winter dormancy. Forcing also provides a good opportunity to learn to identify woody plants by their winter twigs and to observe the often unseen but interesting flowers of non-showy trees and shrubs.

PURPOSE AND BACKGROUND

The data in this paper serve two purposes. The first is to be of practical use to teachers in obtaining and determining approximate forcing times for specific woody plants, and noting which species give relatively good results; and the second is to be a preliminary guide for researchers interested in the problem of dormancy in woody plants. In regard to the latter, I have included data indicating when flower buds swell which do not open. These cases would be prime targets for experimental manipulation. It is beyond the scope of this article to discuss the physiological phenomena associated with dormancy in detail. However, a brief summary of some salient points might prove beneficial here.

Dormancy has been defined by Wareing (1969) as that phase in the life-cycle of a plant in which active growth is temporarily suspended due to external and internal factors. The external factors are temperature, photoperiod (day-length), quality of light, temperature during light and dark periods, nutritive conditions, and water supply, and they usually have a combined effect (Vegis, 1964). The internal factors include hormones, particularly gibberellin, and internal inhibitors. It seems that once dormancy is induced, and winter resting buds are formed, as in late summer by shortening days, chilling is usually required to break dormancy, at least in species from cold climates. Once the minimum chill requirement is fulfilled, longer days and gradually increasing temperatures, as in spring, promote bud break. In addition, dormancy can be overcome by the external application of several

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substances, including gibberellic acid and ethylene; and immersion in warm water (40°C, 104°F) for several hours is also effective (Wareing, 1969). More experimentation should be done with forcing temperatures, since, as buds emerge from dormancy, they will grow at first only over a narrow range of temperatures; while later they can tolerate a much wider temperature range (Wareing, 1969). Additional information on this topic may be found in the works of Samish (1954), Weaver (1972), Wareing (1956), Wareing & Saunders (1971), and Wilson (1970). Some general knowledge of dormancy physiology would prove helpful to anyone planning to force twigs.

METHODS

The techniques involved can be adapted to different situations. Any variation in the following specifications, however, may alter forcing time. Indeed there are many factors involved, about which we have little practical information, that affect forcing time and flower quality. At the University of Michigan a small greenhouse is used where the twigs, up to one meter long, are brought in immediately after cutting and stood together uncrowded (and untied) in galvanized 3-gallon buckets of tap water. It is important not to let the cut ends dry out for long, or to make a fresh cut so they can take up water. The temperature is maintained at 18° ± 3°C (65° ± 5°F), or warmer on sunny days. The lower the temperature, the better the forcing as the new leaves tend to wilt if it becomes too warm. A battery of lights, both incandescent (250-watt bulbs) and fluorescent (40-watt tubes), is suspended close above the twigs and operated by a timer which provides 18 hours of light per day. No critical experiments have been done by me to determine the value of the extra light, but it probably helps by creating spring-like long days (known to be important in breaking dormancy) and adding local warmth which can be used for quicker forcing of some twigs. A most important factor is humidity. The twigs are misted every day, preferably two or three times a day, with *warm* water (ca. 40°C, 104°F). In 1974 an experiment was done with two nearly identical sets of ten different species, keeping one set dry and misting the other twice a day, all other factors being equal. All but one of the dry twigs failed to open flowers, and new leaves soon wilted. The misted twigs forced normally, producing good flowers and/or leaves.

In some cases, forced flowers are apparently perfectly normal; in most cases, however, they are somewhat smaller and less numerous than in nature. This is to be expected since normal flower and leaf enlargement merely involves increase in size of preformed cells (in the bud) by turgor pressure from the vascular system of the supporting branch, trunk, roots, etc.

One other precaution: when collecting, make sure to gather twigs with *flower* buds! Some species have separate leaf and flower buds (e.g., *Fraxinus, Juglans,* and *Populus*), and of those plants which do not form separate buds, some do not produce flower primordia in all buds (e.g., *Salix* and *Sassafras*). Dissect representative buds and look for embryonic floral tissue. When planning a forcing schedule, it is best to be liberal with time. Forced twigs can always be kept in a cold room for several days until needed, but it is more difficult to speed up forcing when time runs short. We do not know what accounts for the occasional differences in forcing times for the same species from year to year—in some cases the twigs were collected from the very same plants. See McWilliams and Ludwig (1972) for the results of a three-year phenological study on naturally growing plants. One noticeable trend however, is that the later in the season the twigs are collected, the shorter the forcing time. This shortening of forcing time may be attributable to natural increase in photoperiod, longer exposure to critical chill period, or increased chances of being exposed to naturally warmer days.

COLLECTING AND IDENTIFYING TWIGS

Many twigs of species in Table 1 were collected from cultivated plants at The University of Michigan campus, Nichols Arboretum, and the Matthaei Botanical Gardens, all at Ann Arbor. These plants provide a ready source for judicial collecting of some genera and species absent or not easily obtainable from native habitats in southeastern Michigan. These include *Alnus glutinosa* (Alder), *Amelanchier* (June-berry), *Berberis* (Barberry), *Betula pendula* (European Birch), *Calycanthus* (Carolina Allspice), *Cercis* (Redbud), *Chaenomeles* (Quince), *Cornus mas* (Cornelian-cherry), *Forsythia, Ginkgo, Magnolia* ×*soulangeana, Syringa* (Lilac), and *Ulmus americana* (American Elm). In addition, cultivated plants of *Fraxinus americana* (White Ash), *Juglans* (Walnut), *Lonicera* (shrubby Honeysuckle), *Malus* (Crabapple), *Prunus* (Cherry), and *Spiraea* seem to force easier and produce larger flowers than their wild relatives.

Other twigs were collected from native and naturalized plants growing in the natural areas at the Matthaei Botanical Gardens, including floodplain species like *Acer negundo* (Box-elder), *Ribes americanum* (American Black Currant), *Viburnum trilobum* (High-bush Cranberry), and *Zanthoxylum americanum* (Prickly-ash); and upland species such as *Catalpa, Corylus americana* (Hazelnut), *Prunus serotina* (Black Cherry), and *Rhus aromatica* (Fragrant Sumac). Mud Lake Bog, just west of Whitmore Lake in northern Washtenaw County, and other bogs and marshes provided many fine and reliable specimens of *Aronia* (Chokeberry), *Cephalanthus* (Buttonbush), *Chamaedaphne* (Leatherleaf), *Betula pumila* (Dwarf Birch), *Larix laricina* (Larch), *Nemopanthus* (Mountain-holly), and *Vaccinium corymbosum* (High-bush Blueberry). Various mesic woods in the area were the sources of such species as *Asimina* (Paw paw), *Lindera* (Spice-bush), *Ostrya* (Hop-hornbeam), and *Sassafras,* while plants like *Populus* spp. (Aspens and Cottonwood), *Carya* spp. (Hickories), and *Quercus* spp. (Oaks) can easily be found along roadsides and fence rows.

There are numerous books and articles on twig identification. The most useful ones for the beginner are those which contain good pictures of the twigs, such as Campbell, Hyland, and Campbell (1975), Core and Ammons (1958), Harlow (1959), and Symonds (1958, 1963), but see Wells (1965) for a very usable non-illustrated winter twig key. Rogers (1965) presents some fine close-up photos of tree flowers which would be of some help. When attempting to identify winter twigs, it is often rewarding to look for old fruits and leaves on the plant, and those on the ground immediately beneath the plant might give clues. Experience using the keys with *many* different species, for comparisons, is the best way to learn them by twig characters.

EXPLANATION OF TABLE

In Table 1, entries are made for winter 1973, 1974 (*), and 1975 (†), when available. Multiple entries are made to give an idea of variation in forcing times. Nomenclature follows Rehder (1940). In the case of dioecious plants ♂ or ♀ indicates which sex was forced; [♂&♀] indicates monoecious species. The second column gives the date the twigs were brought into the greenhouse. The third column notes information about bud swelling, e.g., the first date noticeable swelling occurred. The fourth column gives the date on which the first flower (or several flowers or gymnosperm cone) opened, and indicates whether flowers (fl.) [(fls.) if both sexes on monoecious plants], or leaves only (lf.) were produced. X indicates that the new growth died before producing flowers or fully expanded leaves and the twigs were discarded on the date indicated. If flower buds were produced, but never opened, this is so noted. The fifth column gives the minimum forcing time for each entry. In many cases more flowers will open during the several days following initial opening and in some species (e.g., *Amelanchier canadensis*) flowers may be produced for up to ten days. If only leaves are produced, no time is given. ! in the sixth column means that we had very good luck forcing that particular species, resulting in numerous flowers of good quality. I would appreciate hearing from anyone experimenting with forcing twigs in this manner.

TABLE 1. Twigs forced in winter 1973, 1974 (*), and 1975 (†).

Species	Date brought in	Comments	1st flower (or lf only)	Forcing time (days)	Good
*Acer ginnala	Mar 2	Mar 20–buds large	Mar 28–fl.	26	
A. negundo ♂	Feb 21		Mar 8–fl.	16	!
*A. negundo ♂	Feb 13		Mar 9–fl.	24	!
*A. negundo ♀	Mar 2		Mar 18–fl.	16	
†A. negundo ♂	Mar 12	Mar 20–buds open	Mar 27–fl.	16	!
†A. negundo ♀	Mar 23		Apr 7–fl.	16	
A. platanoides	Jan 10	Feb 3–buds swell	Feb 13–fl.	35	!
A. platanoides	Jan 21	Feb 4–buds swell	Feb 13–fl.	24	
*A. platanoides	Jan 22	Feb 1–buds swell	Feb 22–fl.	32	!
†A. platanoides	Feb 6		Feb 27–fl.	22	!
†A. platanoides	Mar 2	Mar 17–buds open	Mar 22–fl.	21	!
A. rubrum ♂	Feb 24		Feb 29–fl.	6	!
A. saccharinum ♂	Feb 21		Feb 27–fl.	7	!
*A. saccharinum ♀	Feb 22		Feb 25–fl.	4	!
†A. saccharinum ♀	Mar 22		Mar 25–fl.	4	!
A. saccharum [♂&♀]	Jan 21	Feb 4–buds swell	Feb 13–lf.		
*A. saccharum [♂&♀]	Jan 29	Feb 14–buds swell	X Mar 1		
Aesculus hippocastanum	Feb 7		X Mar 1		
†A. hippocastanum	Feb 14	Mar 23–buds swell	Apr 1–lf.		

TABLE 1 (Continued).

Species	Date brought in	Comments	1st flower (or lf only)	Forcing time (days)	Good
Ailanthus altissima	Jan 26	Feb 5–buds swell	Feb 15–lf.		
Alnus glutinosa [♂&♀]	Jan 18		Jan 28–fls.	11	!
*A. glutinosa [♂&♀]	Feb 27		Mar 8–fls.	10	!
†A. glutinosa [♂&♀]	Mar 19	Mar 20–buds swell	Mar 25–fls.	7	!
Amelanchier canadensis	Feb 7	Feb 11–buds swell	Feb 23–fl.	17	
*A. canadensis	Feb 5	Feb 15–buds swell	Feb 28–fl.	24	!
*A. canadensis	Feb 27	Mar 8–buds swell	Mar 24–fl.	26	
†A. canadensis	Feb 1	Feb 12–buds swell	Feb 24–fl.	24	!
†A. canadensis	Mar 2	Mar 7–buds swell	Mar 20–fl.	19	!
A. sanguinea	Jan 20	Jan 24–buds swell	Feb 5–fl.	17	!
*A. sanguinea	Mar 2	Mar 12–buds swell	Mar 28–fl.	27	
*Aronia melanocarpa	Feb 1	Feb 15–buds swell	Mar 2–fl.	30	!
†A. melanocarpa	Feb 1	Feb 12–buds swell	Mar 2–fl.	30	
*Asimina triloba	Dec 27	Jan 15–buds swell	Feb 14–fl.	50	!
†A. triloba	Dec 19	Jan 10–buds swell	Jan 31–fl.	40	!
†A. triloba	Feb 14	Feb 28–buds swell	Mar 28–fl.	43	!
Berberis thunbergii	Jan 14	Jan 23–buds swell	Feb 17–fl.	25	
*B. thunbergii	Dec 27	Jan 6–buds swell	Jan 20–fl.	25	
Betula lutea [♂&♀]	Jan 20	Feb 1–buds swell	Feb 5–fls.	17	
B. pendula [♂&♀]	Feb 8		Feb 25–fls.	18	
B. pendula [♂&♀]	Feb 23		Mar 13–fls.	19	!
*B. pendula [♂&♀]	Feb 24		Mar 12–fls.	17	!
†B. pendula [♂&♀]	Mar 12	Mar 16–buds swell	Mar 25–fls.	14	!
B. pumila [♂&♀]	Feb 4		Feb 16–fls.	13	!
Calycanthus fertilis	Jan 18	Feb 2–buds swell	Jan 30–lf.		
*C. fertilis	Dec 27	Jan 18–buds swell	Feb 6–fl.	42	!
†C. fertilis	Dec 27	Jan 15–buds swell	Feb 5–fl.	41	!
Carpinus betula [♂&♀]	Feb 24	Mar 3–buds swell	Mar 13–fls.	18	
*C. betula	Mar 2	Mar 9–buds swell	Mar 31–lf.		
Carya cordiformis [♂&♀]	Jan 15		Feb 28–lf.		
*C. glabra [♂&♀]	Feb 2		Mar 30–fl.♂	57	
*C. glabra [♂&♀]	Feb 17		Apr 12–fl.♂	55	
†C. ovata [♂&♀]	Feb 1	Mar 17–buds swell	Apr 2–fl.♂	61	
Catalpa speciosa	Jan 18		Feb 25–fl.	39	
*C. speciosa	Feb 16	Mar 2–buds open	Mar 21–fl.	34	
†Celtis occidentalis [♂&♀]	Feb 14		Mar 20–lf.		
Cercis canadensis	Jan 17	Jan 31–buds large	Feb 7–fl.	22	!
C. canadensis	Feb 4	Feb 12–buds large	Feb 24–fl.	21	!
*C. canadensis	Jan 29	Feb 10–buds large	Feb 18–fl.	21	!
†C. canadensis	Feb 1	Feb 20–buds large	Feb 22–fl.	22	
†C. canadensis	Feb 2	Feb 20–buds large	Feb 28–fl.	27	
†C. canadensis	Mar 2	Mar 12–buds large	Mar 26–fl.	25	
Chaenomeles japonica	Jan 21	Feb 2–buds swell	Feb 6–fl.	17	!
†C. japonica	Feb 1		Feb 19–fl.	18	!
†C. japonica	Mar 2	Mar 12–buds large	Mar 21–fl.	20	!

TABLE 1 (Continued).

Species	Date brought in	Comments	1st flower (or lf only)	Forcing time (days)	Good
Chamaedaphne calyculata	Feb 4	Feb 6–buds swell	Feb 15–fl.	12	!
*C. calyculata	Feb 1		Feb 15–fl.	15	!
†C. calyculata	Feb 1		Feb 15–fl.	15	!
†Chionanthus virginicus	Feb 1	Feb 28–buds large	Mar 25–fl.	53	!
Cornus florida	Jan 17	Feb 4–bracts open	Feb 9–fl.	24	
C. florida	Jan 26	Feb 1–buds swell	Feb 15–fl.	21	
*C. florida	Feb 5	Feb 28–bracts open	Mar 3–fl.	27	!
†C. florida	Feb 1	Feb 25–bracts open	X Mar 9		
C. mas	Feb 14	Feb 17–buds large	Feb 21–fl.	8	!
*C. mas	Feb 16		Feb 22–fl.	7	!
†C. mas	Mar 10		Mar 14–fl.	5	!
C. racemosa	Jan 15	Feb 7–buds large	fl. not open		
*C. racemosa	Feb 16	Mar 10–buds large	fl. not open		
†C. racemosa	Feb 1	Feb 21–buds large	fl. not open		
C. stolonifera	Jan 15	Feb 7–buds large	fl. not open		
*C. stolonifera	Jan 23	Feb 21–buds large	fl. not open		
†C. stolonifera	Feb 1	Feb 25–buds large	fl. not open		
Corylus americana [♂&♀]	Jan 18		Jan 24–fls.	7	!
*C. americana [♂&♀]	Mar 2		Mar 8–fls.	7	!
†C. americana [♂&♀]	Mar 19		Mar 23–fls.	5	!
*Cotoneaster divaricata	Feb 5		Feb 18–lf.		
Crataegus phaenopyrum	Feb 7	Feb 25–buds large	fl. not open		
Crataegus sp.	Jan 15	Feb 3–buds swell	Mar 8–fl.	53	
Euonymus europaea	Jan 26	Feb 9–buds large	fl. not open		
*E. europaea	Feb 27	Mar 2–buds swell	Mar 12–fl.	14	
Exochorda racemosa	Jan 26	Feb 5–buds large	fl. not open		
Forsythia sp.	Jan 17		Jan 25–fl.	9	!
*Forsythia viridissima	Mar 11		Mar 17–fl.	7	!
*Fraxinus americana	Feb 17	Mar 8–buds swell	Mar 13–lf.		
*F. americana ♂	Mar 11		Mar 23–fl.	13	!
†F. americana ♂	Mar 22		Apr 5–fl.	15	
*F. pennsylvanica ♂	Feb 27	Mar 9–buds large	Mar 12–fl.	14	
Ginkgo biloba	Jan 17	Feb 8–buds large	Feb 15–lf.		
*G. biloba ♂	Dec 27	Jan 15–buds large	Jan 21–cone	26	!
†G. biloba ♂	Dec 22	Jan 22–buds large	Jan 27–cone	37	!
†Juglans cinerea [♂&♀]	Feb 1	Feb 27–buds swell	Mar 15–fl.♂	43	
J. nigra [♂&♀]	Jan 15		X Mar 1		
*J. nigra [♂&♀]	Feb 2		X Mar 15		
†J. nigra [♂&♀]	Feb 1	Mar 10–buds swell	Mar 20–fl.♂	48	
Kalmia latifolia	Jan 26	Feb 5–buds large	X Mar 1		
Larix decidua [♂&♀]	Jan 18	Jan 25–buds swell	Feb 1–cone	15	!
L. laricina [♂&♀]	Feb 4	Feb 12–buds large	Feb 16–cone	13	!
*L. laricina [♂&♀]	Dec 27	Jan 6–buds large	Jan 17–cone	22	!
L. laricina [♂&♀]	Dec 27	Jan 17–buds large	Jan 22–cone	27	

TABLE 1 (Continued).

Species	Date brought in	Comments	1st flower (or lf only)	Forcing time (days)	Good
Ligustrum sp.	Jan 14	Jan 21–buds swell	X Jan 31		
Lindera benzoin	Jan 10		Jan 30–fl.	21	!
*L. benzoin	Dec 27	Jan 15–buds large	Feb 1–fl.	37	!
†L. benzoin	Dec 27	Jan 11–buds swell	Jan 21–fl.	26	!
Liriodendron tulipifera	Feb 24	Mar 4–buds swell	X Mar 20		
*L. tulipifera	Dec 27	Jan 4–buds swell	Feb 15–lf.		
†L. tulipifera	Dec 22		Feb 5–lf.		
Lonicera fragrantissima	Feb 5		Feb 13–fl.	9	!
Lonicera morrowii	Jan 17		Jan 29–lf.		
L. morrowii	Jan 20		Feb 8–fl.	20	
*L. morrowii	Feb 5		Mar 1–fl.	25	
*L. morrowii	Mar 2	Mar 18–buds swell	Mar 30–fl.	29	
*Maclura pomifera ♀	Jan 20	Feb 28–buds large	Mar 13–fl.	53	!
†M. pomifera	Feb 1	Feb 12–buds swell	Feb 25–lf.		
Magnolia ×soulangeana	Jan 10		Jan 30–fl.	21	!
*M. ×soulangeana	Dec 27	Jan 6–buds swell	Jan 18–fl.	23	!
†M. ×soulangeana	Dec 27		Jan 20–fl.	25	
†M. ×soulangeana	Jan 6	Jan 27–buds large	Jan 31–fl.	26	
Mahonia aquifolium	Jan 14	Jan 21–buds swell	Feb 1–fl.	19	
*M. aquifolium	Dec 27	Jan 10–buds large	Jan 30–fl.	35	!
†M. aquifolium	Dec 27	Jan 16–buds large	Jan 22–fl.	27	
Malus purpurea cv. 'Eleyi'	Jan 14	Jan 25–buds swell	Feb 6–fl.	24	!
M. purpurea cv. 'Eleyi'	Feb 7		Feb 26–fl.	20	
*M. purpurea cv. 'Eleyi'	Jan 29	Feb 4–buds swell	Feb 21–fl.	24	!
†M. purpurea cv. 'Eleyi'	Feb 1	Feb 8–bud swell	Feb 27–fl.	27	
†M. purpurea cv. 'Eleyi'	Feb 20	Mar 1–buds swell	Mar 18–fl.	27	
M. sylvestris	Feb 7	Feb 14–buds swell	Feb 25–fl.	19	
*M. sylvestris	Mar 5		Mar 25–fl.	21	!
†M. sylvestris	Feb 2	Feb 20–buds large	Mar 12–fl.	39	
*Metasequoia glyptostroboides	Feb 16	Feb 27–buds swell	Mar 13–lf.		
†M. glyptostroboides	Dec 27	Jan 17–buds large	Jan 23–lf.		
Morus rubra ♀	Mar 2	Mar 19–buds swell	Mar 31–fl.	30	
†Nemopanthus mucronata ♂	Feb 1	Feb 14–buds swell	Feb 28–fl.	28	!
Ostrya virginiana [♂&♀]	Jan 15		Feb 2–fl.♂	19	
*O. virginiana [♂&♀]	Mar 2	Mar 9–buds swell	Mar 31–lf.		
†Platanus ×acerifolia	Mar 2	Mar 23–buds large	Apr 5–fl.	35	!
Philadelphus sp.	Jan 23		Feb 25–lf.		
*Philadelphus sp.	Mar 2	Mar 9–buds swell	Mar 22–lf.		
Physocarpus opulifolius	Jan 20		Feb 2–fl.	14	
*P. opulifolius	Jan 23	Jan 30–buds large	fl. not open		
†P. opulifolius	Feb 1	Mar 12–buds large	fl. not open		
*Populus deltoides ♂	Feb 27		Mar 12–fl.	14	!
†P. deltoides ♂	Mar 12		Mar 25–fl.	14	!
*P. grandidentata ♀	Mar 6		Mar 11–fl.	6	!
†P. grandidentata ♀	Mar 23		Mar 26–fl.	4	!

TABLE 1 (Continued).

Species	Date brought in	Comments	1st flower (or lf only)	Forcing time (days)	Good
Prunus serotina	Jan 20	Feb 4–buds swell	Feb 11–fl.	23	
*P. serotina	Jan 28	Feb 1–buds swell	X Mar 2		
P. subhirtella var. pendula	Feb 7	Feb 10–buds swell	Feb 24–fl.	18	
†P. subhirtella var. pendula	Feb 1	Feb 12–buds large	Feb 20–fl.	21	!
†P. subhirtella var. pendula	Mar 2	Mar 12–buds large	Mar 22–fl.	21	!
*P. virginiana	Jan 28		Mar 1–fl.	33	
†P. virginiana	Feb 14	Mar 17–buds large	Mar 23–fl.	38	
Quercus alba [♂&♀]	Feb 4		Mar 11–lf.		
*Q. alba [♂&♀]	Jan 26	Mar 1–buds swell	Mar 20–fl.♂	54	
*Q. alba [♂&♀]	Mar 2		Mar 30–fl.♂	29	
†Q. alba [♂&♀]	Feb 14	Mar 12–buds swell	Mar 25–fl.♂	40	
*Q. macrocarpa [♂&♀]	Jan 23	Feb 15–buds swell	Feb 21–lf.		
Q. robur [♂&♀]	Feb 24		X Mar 10		
*Q. rubra [♂&♀]	Jan 28	Mar 1–buds swell	Mar 12–lf.		
*Rhamnus cathartica	Feb 5		Feb 22–lf.		
Rhododendron maximum	Jan 26	Feb 18–buds swell	X Feb 22		
R. catawbiense	Jan 26		X Feb 22		
R. nudiflorum	Jan 17	Feb 18–buds swell	fl. not open		
Rhus aromatica	Jan 18		Jan 30–fl.	13	!
R. aromatica	Feb 19		Feb 25–fl.	7	
*R. aromatica	Feb 16		Mar 1–fl.	14	!
†R. aromatica	Mar 12	Mar 23–buds large	Mar 28–fl.	17	!
*R. glabra	Feb 16	Mar 1–buds swell	Mar 10–lf.		
*R. radicans	Feb 16		X Mar 15		
R. typhina	Jan 15		Feb 3–lf.		
Ribes alpinum	Jan 26	Jan 29–buds swell	Feb 15–fl.	21	!
R. alpinum	Feb 7		Feb 16–fl.	10	!
*R. alpinum	Feb 7	Feb 11–buds swell	Feb 22–fl.	16	!
R. americanum	Jan 24	Jan 30–buds swell	Feb 6–fl.	14	!
*R. americanum	Feb 5	Feb 12–buds swell	Feb 25–fl.	21	!
*R. americanum	Mar 2	Mar 19–buds swell	Mar 25–fl.	24	!
Robinia pseudoacacia	Jan 21	Jan 30–buds swell	Feb 22–fl.	33	!
Rosa sp.	Jan 20		Jan 30–lf.		
Rubus alleghaniensis	Jan 20		Feb 9–fl.	21	
*R. allegheniensis	Feb 5	Feb 16–buds swell	X Mar 12		
*R. occidentalis	Feb 5	Feb 16–buds swell	X Mar 12		
*Salix discolor ♀	Feb 27	Mar 1–buds large	Mar 8–fl.	10	!
†S. discolor ♀	Mar 17		Mar 25–fl.	9	!
Sambucus canadensis	Jan 18		Jan 30–lf.		
*S. canadensis	Feb 27		Mar 21–lf.		
*S. pubens	Jan 20		Feb 18–fl.	30	
Sassafras albidum ♂	Jan 15	Jan 29–buds swell	Feb 18–fl.	35	!
*S. albidum ♂	Dec 27		Feb 5–fl.	41	!
†S. albidum ♂	Dec 27	Jan 20–buds swell	Jan 30–fl.	36	!

TABLE 1 (Continued).

Species	Date brought in	Comments	1st flower (or lf only)	Forcing time (days)	Good
Solanum dulcamara	Oct 15		Dec 15–fl.	62	!
S. dulcamara	Jan 20	Feb 2–roots	Feb 20–fl.	31	!
Smilax tamnoides	Mar 2	Mar 13–buds swell	X Mar 30		
*Spiraea arguta	Feb 5	Feb 12–buds swell	Feb 25–fl.	21	
†S. arguta	Mar 1		Mar 24–fl.	24	
S. ×vanhouttei	Jan 14	Jan 21–buds swell	Feb 19–fl.	37	
*S. ×vanhouttei	Jan 29	Feb 1–buds swell	fl. not open		
Syringa vulgaris	Feb 12		Mar 14–fl.	31	
*S. vulgaris	Dec 27		Feb 10–fl.	46	!
†S. vulgaris	Feb 6	Feb 25–buds large	Mar 12–fl.	35	
†S. vulgaris	Mar 2		Mar 22–fl.	21	
*Taxus baccata ♂	Jan 7		Jan 14–cone	8	!
†T. baccata ♂	Dec 27		Jan 14–cone	19	!
*Ulmus americana	Mar 6		Mar 10–fl.	5	!
†U. americana	Mar 24		Mar 28–fl.	5	!
Vaccinimum corymbosum	Feb 4		X Mar 1		
*V. corymbosum	Feb 1		Feb 24–fl.	24	!
†V. corymbosum	Feb 1	Feb 12–buds swell	Mar 8–fl.	36	
Viburnum lentago	Jan 20	Feb 1–buds swell	Feb 2–lf.		
*V. lentago	Mar 2	Mar 16–buds swell	X Apr 1		
*V. lentago	Feb 16	Feb 18–buds swell	fl. never open		
*V. trilobum	Mar 2	Mar 18–buds swell	Apr 10–fl.	40	
Vitis riparia	Jan 15	Jan 30–buds swell	fl. never open		
*V. riparia	Feb 16	Mar 8–buds large	fl. never open		
Zanthoxylum americanum ♂	Jan 20	Feb 2–buds swell	Feb 17–fl.	29	
*Z. americanum ♂	Feb 16	Mar 1–buds swell	Mar 8–fl.	21	
*Z. americanum ♂	Mar 2		Mar 30–fl.	29	
†Z. americanum ♂	Feb 14	Mar 1–buds swell	Mar 15–fl.	30	

ACKNOWLEDGMENTS

I wish to thank Dr. Warren H. Wagner, Jr. and Dr. L. D. Noodén for reading the manuscript and offering suggestions; James G. Bruce, III, Thomas A. Friedlander, Kerry S. Walter, and Dr. Conrad S. Yocum for twig collections; Richard Turner for help in identifying some of the cultivated woody plants; and my wife Audrey, for accompanying me on numerous collecting trips. Inspiration for beginning and continuing this project came while I was a teaching assistant in Professor Wagner's Systematic Botany course, and through discussion with Dr. Noodén.

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Reviews

PRAIRIE: A MULTIPLE VIEW. Edited by Mohan K. Wali. University of North Dakota Press, Grand Forks. 1975. 433 pp. $10.00, paper cover.

This volume is based on presentations at the IV Midwest Prairie Conference (1974). Six persons are thanked for invitational papers; Cronquist's, however, is not included. Published are 41 diverse papers grouped in sections: (I) Prairie and man; (II) Ecology–Animals, Plants and Soils; (III) Cytogenetics and Taxonomy; (IV) Management, Restoration and Uses. Two papers deal explicitly and extensively with the Great Lakes region: Paul Thompson's, on floristic composition of 10 prairie stands in southern Michigan and Ontario; and Francis Evans', which brings together many data on the natural history of an old field at the George Reserve in Livingston County, with useful bibliography. Both papers include full lists of species and some interpretation. There are brief papers on assorted prairie operations in the Chicago and Milwaukee areas, general papers (e.g., on fire), and a vegetative key to Nebraska grasses.

NATIVE GRASSLAND ECOSYSTEMS EAST OF THE ROCKY MOUNTAINS IN NORTH AMERICA: A PRELIMINARY BIBLIOGRAPHY. By Richard H. Pemble, Ronald L. Stuckey, and Lynn Edward Elfner. A Supplement to Prairie: A Multiple View. [University of North Dakota Press, Grand Forks. 1975]. 466 pp. $7.00, paper cover.

Nearly 7000 references are cited, without annotations and without any index or subject-matter breakdown. They are alphabetical, with each letter including a section of "additions which were made after the first draft was typed."

–E. G. V.

GYPSOPHILA SCORZONERIFOLIA (CARYOPHYLLACEAE), A NATURALIZED SPECIES IN THE GREAT LAKES REGION[1]

James S. Pringle
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A species of *Gypsophila* L. not included in North American floras has become extensively naturalized in Presque Isle County, Michigan, as well as being locally established elsewhere in the Great Lakes region. Specimens from this region have generally been identified as *G. acutifolia* Stev. ex Spreng., and were reported as that species by Voss (1957a, b). Discrepancies between these specimens and descriptions of *G. acutifolia,* however, have indicated the need for re-examination.

The most recent and most thorough taxonomic treatment of *Gypsophila* is the world monograph by Barkoudah (1962), who also collaborated in the treatment of this genus in the Flora Europaea (Barkoudah & Chater, 1964). Another important taxonomic reference is Shishkin's (1936) treatment of *Gypsophila* in the Flora of the U.S.S.R. According to these works, the plants in question are *G. scorzonerifolia* Ser., a species native to the Lower Volga and Ciscaucasian regions of the Soviet Union, north and west of the Caspian Sea. A specimen collected in the present study, *Pringle 1604* (LTR), was examined, and its identity as *G. scorzonerifolia* confirmed, by A. O. Chater, who noted that this specimen closely matched specimens from the Soviet Union (in litt., 1976). Previously, *Thieret 1404* (GH) had been tentatively identified as *G. scorzonerifolia* at the Royal Botanic Gardens, Kew.

Gypsophila scorzonerifolia (Fig. 1) is a deep-rooted perennial, producing short vegetative shoots and much-branched flowering stems usually 0.4-1 m tall. The leaves are glaucous. Numerous glands are present on the cyme branches, pedicels, and calyces. In the populations I have observed, the petals were distinctly pale pink when fresh, although Voss (1975b) recorded that the corollas of his no. *2741* were white when collected, turning pink after a few hours in the vasculum. The purplish-pink color becomes deeper as the corollas dry.

In the key to *Gypsophila* species in the Flora Europaea (Barkoudah & Chater, 1964), a couplet pertaining to the relative lengths of the pedicels and calyces has presented problems in the identification of *G. scorzonerifolia.* In this key, the term "pedicels" evidently refers to the ultimate divisions of the inflorescence, measured from the point of branching; these vary in length, but average about twice as long as the calyces. If measured distally to the bractlets which are present on some of these branches, the "pedicels" are only about as long as the calyces.

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[1]Contribution from the Royal Botanical Gardens, Hamilton, Ontario, Canada, No. 25, and from the University of Michigan Biological Station.

Fig. 1. *Gypsophila scorzonerifolia*, between U.S. Hwy. 23 and Lake Huron ca. 5 km NW of Rogers City, Presque Isle County, Michigan, photographed 5 Aug 1975.

TABLE 1. *Gypsophila* species contrasted.

Character	*G. acutifolia*	*G. paniculata*	*G. perfoliata*	*G. scorzonerifolia*
Glandularity	Stems glabrous below, glandular above; pedicels glabrous or glandular; calyx usually glabrous, occasionally glandular	Stems usually glabrous, rarely glandular below; pedicles and calyces glabrous	Stems usually glandular below, glabrous above, rarely glabrous throughout; pedicels and calyces glabrous	Stems glabrous below; pedicels and calyces glandular
Leaves (larger)				
Length	20-80 mm	20-70 mm	20-80 mm	20-100 mm
Width	2-10 (–15) mm	2.5-10 mm	10-35 mm	10-20 mm
Base	Narrowed, not clasping	Narrowed, not clasping	Broad, clasping	Broad, clasping
Apex	Long-acuminate	Acuminate	Obtuse to abruptly acute	Obtuse to abruptly acute
Calyx				
Length	3-3.5 mm	1.5-2 mm	2-2.5 mm	2.5-4 mm
Apex of lobes	Acuminate	Obtuse	Obtuse	Obtuse
Petals				
Length	6-7 mm	2-3.5 mm	4-5 mm	4-6 mm
Color	White	Usually white, rarely pink	White or pale purplish-pink	Pale purplish-pink or white, drying purplish-pink
Seed-coat tubercles	Prominent, acute	Prominent, obtuse	Minute	Prominent, obtuse

Misidentification of North American specimens of *G. scorzonerifolia* has in most cases been due to the use of references in which this species was not mentioned. Chater (in litt., 1976) considers *G. scorzonerifolia* to be "a quite distinct species," and says that he is "not aware of any other with which it could be confused."

Previous nomenclatural problems (noted by Shishkin, 1936) and misidentifications have obscured the horticultural history of *G. scorzonerifolia.* It is, however, known to be cultivated far beyond its natural range (Synge, 1956), and was probably introduced to the Great Lakes region as an ornamental.

In Table 1, *G. scorzonerifolia* is contrasted with *G. acutifolia*; *G. paniculata* L., the common Baby's Breath, which is naturalized in much of North America, including the northern part of the Lower Peninsula of Michigan; and *G. perfoliata* L., a species closely related to *G. scorzonerifolia,* also reported to be naturalized in North America. All traits listed as being

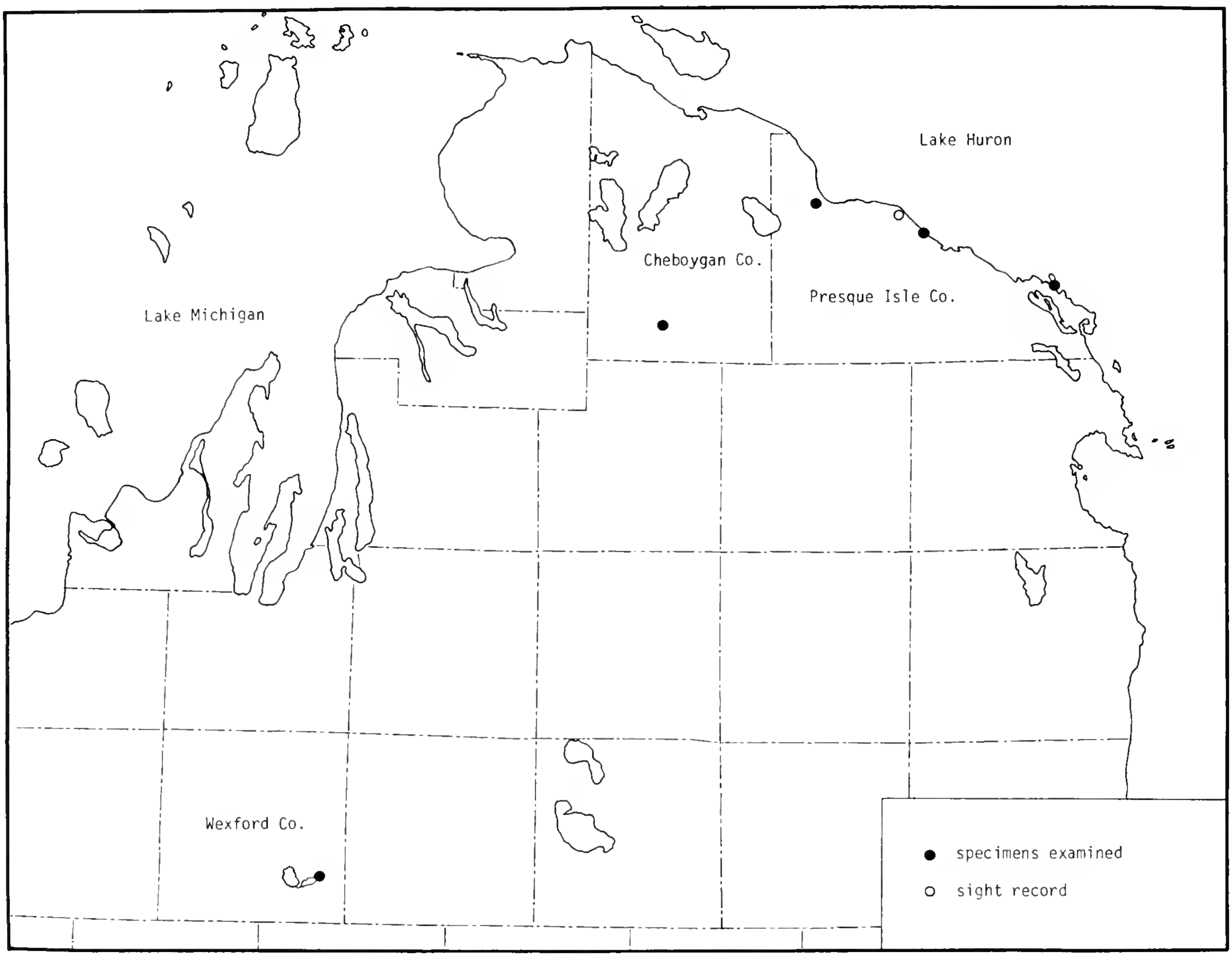

Fig. 2. Distribution of *Gypsophila scorzonerifolia* in the northern part of the Lower Peninsula of Michigan. (This species has also been collected in Houghton County, Michigan, and Lake County, Indiana.)

characteristic of *G. scorzonerifolia* have been noted in the plants of the Great Lakes region.

Specimens of *G. scorzonerifolia* from the Great Lakes region are listed below. Abbreviations for herbaria follow Holmgren and Keuken (1974); those in square brackets refer to duplicates reported by Voss (1957a; in litt., 1976), not examined in the present study.

INDIANA: LAKE CO.: along NYC railroad tracks N of Hwy. 12, 1.5 mi E of Lake Street, Gary, *Thieret 1404,* 2 July 1955 (F, GH) and (same no.) 19 July 1955 (F).

MICHIGAN: CHEBOYGAN CO.: weedy roadside across from dilapidated (but occupied) farm, N edge, NE¼, Sec. 10, W½ Nunda Tp., ca. 3 mi E of Wolverine, *Voss 2741,* 16 July 1955 (MICH, [SMU], UMBS). HOUGHTON CO.: on cindery stamp sands at Dollar Bay, *Voss 14713,* 7 Aug 1975 (HAM, [MICH, MSC]). PRESQUE ISLE CO.: along Presque Isle Co. road 646 where it crosses the swamp between Mud Lake and Orchard Lake, Sec. 24, T36N R2E, *Pringle 184,* 25 July 1963 (UMBS), and *Pringle 649,* 5 Aug 1966 (HAM, MICH); shore of Lake Huron ca. 5 km NW of Rogers City, Sec. 31, T36N R5E, *Pringle 1604,* 5 Aug 1975 (HAM, LTR, MICH, TRT); dunes along County road 405 at Presque Isle Harbor Beach, ca. 4.2 km NNW of Presque Isle village, Sec. 17, T34N R8E, *Pringle 1603,* 7 Aug 1975 (HAM). WEXFORD CO.: edge of lake, Cadillac, *Dreisbach 7454,* 9 Aug 1931 ([FHKSC], MICH, [USC]).

All of the plants which I have observed in the field were growing in deep, loose, dry sand, either on dunes or in roadside fill. The dune populations near Rogers City and Presque Isle comprised hundreds of plants in 1975. Here, *G. scorzonerifolia* was associated with native dune species, such as *Calamovilfa longifolia* (Hook.) Scribn. var. *magna* Scribn. & Merr., *Hypericum kalmianum* L., and *Solidago houghtonii* A. Gray. Near Wolverine, *G. scorzonerifolia* was reported to be "locally common" along a roadside and also "running wild . . . and thoroughly established" in a farmyard across the road, from which it was believed to have escaped (Voss, 1957a). This species was also said to be "common" at Dollar Bay (Voss, on label), where the "stamp sands"–pulverized rock discarded in ore-processing operations–constitute an artificial habitat, in contrast to the natural dune sands in Presque Isle County. In Indiana, *G. scorzonerifolia* was encountered "in a dense colony about 120 feet long along the RR tracks" (Thieret, on label), where it was associated with *Equisetum hyemale* L., *Chenopodium botrys* L., *Salsola kali* L., *Mirabilis nyctaginea* (Michx.) MacM., *Silene cucubalus* Wibel, *Euphorbia corollata* L., *E. maculata* L., and *Chaenorrhinum minus* (L.) Lange, all of which are associated with sand, gravel, and coarse fill, and most of which are rapid colonizers of disturbed sites. An indication of the rapidity with which *G. scorzonerifolia* may spread was obtained at Mud Lake, where only two plants, one of which was collected, were seen in 1963. By 1966, over one hundred plants were present. In 1975, however, this colony was greatly reduced, perhaps as a result of the timing and closeness of roadside mowing during the intervening years.

ACKNOWLEDGMENTS

I am very grateful to Mr. A. O. Chater for confirming the identification of the specimen sent to LTR, and to Dr. Edward G. Voss for valuable information and suggestions, and for making a recent collection available for study. Cited letters are in the archives of the Royal Botanical Gardens.

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Publications of Interest

AN INDEX OF THE COMMON FUNGI OF NORTH AMERICA (SYNONYMY AND COMMON NAMES). By Orson K. Miller, Jr., and David F. Farr. Bibliotheca Mycologica 44. J. Cramer, Vaduz, [Liechtenstein]. 1975. 206 pp. DM 37.50, paper cover. Drs. Miller and Farr have indexed the scientific names used for species of macrofungi in 30 books and pamphlets published in the period 1897-1974 and intended primarily for amateur mycologists. Synonyms are cross-referenced, and common English names given where available. The book, which is reproduced by offset from typewritten script, will help amateurs out of some of the confusion caused by usage of more than one name for a single species and will often enable them to determine the name that reflects a species' position in the modern system of classification of higher fungi. An introductory section explains the workings of the International Code of Botanical Nomenclature. This discussion does include a major misconception that the general reader should be aware of, namely, that types are designated for taxonomic *groups* such as species. They actually apply to the *names* of groups. The difference is significant.

—Robert L. Shaffer

THE PYRENOMYCETOUS FUNGI. By Lewis E. Wehmeyer. Edited by Richard T. Hanlin. Mycologia Memoir 6. J. Cramer, Lehre, Germany. 1975. 250 pp. DM 80.00 (special price of $20.00 to members of Mycological Society of America). At the time of his death in 1971, Prof. L. E. Wehmeyer, of the University of Michigan Botany Department, left a lengthy manuscript on the ascomycetous fungi, on which he had specialized in his some 50 years as a mycologist. The manuscript was mostly based upon his research on fruit-body development and taxonomy of some of these fungi and upon lecture notes and laboratory outlines for the advanced mycology course that he taught prior to retiring in the mid-1960's. It was edited by a group headed by one of his former graduate students, Dr. Richard T. Hanlin.

Classification of the Ascomycetes exclusive of the Discomycetes is the book's theme. Keys are given to orders, families, and genera; and the taxa are characterized briefly. Discussions of some of them also provide information on topics such as reproductive biology, developmental morphology, and plant pathology. The book has its principal value in the presentation of Professor Wehmeyer's ideas on relationships within the largest, most diverse group of fungi; and it fittingly commemorates him as one of their best known students.

—Robert L. Shaffer

ZUR ÖKOLOGIE DER PORLINGE. By Ingo Nuss. Bibliotheca Mycologica 45. J. Cramer, Vaduz, [Liechtenstein]. 1975. 258 pp., paper cover. DM 50.00. This booklet, in German, on the ecology of the Polypores, gives much valuable data on periods of sporulation, temperature requirements, and rate of fruit-body development of many of the common species found in Michigan, such as *Piptoporus betulinus, Phellinus igniarus, Oxyporus populinus,* etc. Good photographs of spores are included.

—Alexander H. Smith

MOSSES OF THE GREAT LAKES FOREST. By Howard Crum. Revised ed. University Herbarium, University of Michigan, Ann Arbor. 1976. 404 pp. $8.00 [plus $.50 for domestic mailing, $.75 for foreign mailing, $.32 sales tax in Michigan]. This is a thorough revision (about half the pages altered, some plates redone) of the work reviewed in this journal in 1974 (13: 166). Not only is the text updated, but the paper and binding are also improved. The fact that the original edition sold out so rapidly attests to the value of this work as a manual of the mosses of the Great Lakes-St. Lawrence region, with special emphasis on Michigan.

VERTEBRATE ANIMAL POPULATIONS OF THE McCORMICK FOREST. By William L. Robinson and J. Kirwin Werner. U.S. Forest Service Res. Pap. NC-118. 1975. 25

pp. This work surveys birds, mammals, reptiles, and amphibians in the 17,000-acre experimental forest in Baraga and Marquette counties (see Mich. Bot. 10: 94, 142. 1971).

PRIMARY FOREST PRODUCTS INDUSTRY AND TIMBER USE, MICHIGAN, 1972. By James E. Blyth, Allan H. Boelter, and Carl W. Danielson. U.S. Forest Service Resource Bull. NC-24. 1975. 45 pp. Discusses recent Michigan forest industry trends, with extensive data by species and county on production of pulpwood, saw logs, veneer logs, and other roundwood products. Compares saw log production in 1969 and 1972 and discusses wood-using plant residue and its disposition.

A CATALOGUE OF PLANTS & SHELLS, FOUND IN THE VICINITY OF MILWAUKEE, ON THE WEST SIDE OF LAKE MICHIGAN. By I. A. Lapham. Facsimile of 1836 edition, published by the Botanical Club of Wisconsin, c/o Wisconsin Academy, 1922 University Avenue, Madison 53705. 1976. 12 pp. $5.00. This attractively prepared facsimile of "the first publication of a scientific character within the present state of Wisconsin" was made from the copy presented by its author, Wisconsin's distinguished pioneer naturalist (and correspondent of Douglass Houghton), to his future wife, Ann M. Allcott, of Marshall, Michigan. The list of plants is essentially unannotated but nevertheless of historic interest.

INDEX TO VOLUMES 13-15

With the exceptions here noted, this index intends to be complete for the three volumes, including all scientific names of genera and species, titles (by important words), authors, and subjects. NOT indexed, in general, are the following: news items, editorial notes, items in literature lists or summaries, common names or names of taxa higher than genus or lower than species except where there is a major discussion or use of them or they appear in titles. Reviews are listed only, by title, under "Reviews"—not under the author or title of the work reviewed nor under the reviewer's name. "Publications of Interest" are not listed by title, although that general heading is indexed. Pictures are indexed under the explanations (whether on the same page, a facing page, or in the case of cover pictures, the rear cover). If an article has three or more authors, the others are cross-referenced to the senior author without repetition of title; if there are only two authors, both are fully indexed with title. Names of persons not followed by a title or cross-reference indicate information about the person. Most other references to persons (e.g., those cited in articles or acknowledgments) are not indexed.

Species mentioned in passing or in habitat descriptions are generally not indexed, especially if the point does not appear to have been documentation of ecological, taxonomic, or distributional information about these species. If a paper includes a checklist of species, additional mention of the species in text or tables is usually not additionally indexed. Thus, species mentioned in the vegetation of Sandhill Woodlot (15: 131-140) are not indexed in addition to their inclusion in the checklist for that area (15: 195-204). Also not indexed are species mentioned as occurring in the habitats on North Fox Island (14: 203-214) or genera and species in the lists of greenhouse plants, forced plants, and other teaching materials (15: 115-120, 208-213).

All new names and new combinations appear in **bold face** type.

The attention of phytogeographers is called to the special entry "Distribution Maps," where all species are listed for which maps have been published showing distribution over an area larger than a single county.

Aberrant Pistillate Catkins of Betula alleghaniensis, 13: 177-179
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  pensylvanicum, 14: 15, 171; 15: 26
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Information for Authors

THE MICHIGAN BOTANIST is distributed not only to a considerable number of individual and institutional subscribers domestically and abroad, but also to all members of the Michigan Botanical Club, an organization composed in large part of non-professionals with concerns for conservation and nature study as well as the local flora. (Total paid circulation exceeds 1000). Considering the range of interests among members and subscribers, we seek to include (in each year if not each issue) the widest possible range of subject matter in regard both to the entire plant kingdom and to branches of the field of botany.

Articles should, in general, include some new botanical information, and should pertain to the Upper Great Lakes region. Not acceptable are manuscripts of primarily literary nature (including all poetry and articles of an "editorial" orientation). Notes on techniques useful to the teacher and hobbyist are welcomed, as is material of biographical and historical nature.

To promote clarity to non-technical readers (without sacrifice of accuracy and precision), such means are encouraged as illustrations, inclusion of a generally accepted "common name" (when such exists) at least once in the title or text of any article devoted to consideration of one or a few species, and introductory material placing the author's studies in perspective and briefly indicating their significance. Summaries, especially of long or complex papers, are desirable.

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Page proof is sent to authors (at least in North America) and must be checked for errors and returned promptly; major revisions cannot be made at this time. Reprints (extracted pages, stapled, including extraneous matter) can be supplied at prices established by the printer. Ordering instructions are supplied after acceptance of an article.

—The Editorial Board

INDEX NOTICE

To Librarians, Subscribers, and Binders

In this issue is a single cumulative index to volumes 13, 14, and 15 of *The Michigan Botanist*—our fifth triennial index. These three volumes may thus be bound together as a convenient unit with a single index. Note that all covers are included in the pagination and should be bound in. There are no special title pages.

Editorial Notes

Users of the big three-year index in this number will share the gratitude of the editor to those who made it possible, Mary Cooley and Dorothy Greenwald, who cut and pasted and alphabetized the more than 2,000 entries, often with several references for each.

This number completes the first 15 volumes of *The Michigan Botanist,* which have included exactly 3,000 printed pages. As announced in the previous number, this is the present editor's last. Howard Crum is already at work on the next one, as this one goes to press. If authors are as patient with him as they have been with me, and as expeditious returning manuscript revisions and proofs, it will help to make his task as pleasant as mine has been. The willingness of one with his editorial skills to take over has made it easier for me to relinquish something to which I have been so close—and to devote more time to the *Michigan Flora.* This has been a rather personalized journal and I have considered it a privilege to count almost all the authors among my friends and/or correspondents—apart from their contributions which have kept the *Botanist* filled with material. My thanks go to all of them, to the wonderfully helpful and skillful composition department at Braun-Brumfield, Inc., to the Michigan Botanical Club and the Editorial Board for their support, and especially to our efficient and hard-working business and circulation manager for all these 15 years, Laura Roberts, who regularly confronts mountains of records and keeps our subscribers happy.

—E. G. V.

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THANKS TO REVIEWERS

One of the chief functions of members of the Editorial Board is to review manuscripts submitted for publication, considering botanical content, clarity of presentation, and suitability for this journal. Editorial policy has called for every manuscript to be reviewed by at least one person competent in the area of its subject matter. Reviewers are by tradition anonymous, but the editor takes this opportunity to express his appreciation to those who served on the Editorial Board during the past three years (marked with an asterisk) as well as to all others in the list below, who have served as advisory reviewers for one or more articles submitted for volumes 13-15:

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(On the cover: Ripe blueberries, Vaccinium lamarckii. *Michigan Department of Natural Resources photo by Bob Harrington, 1960.)*